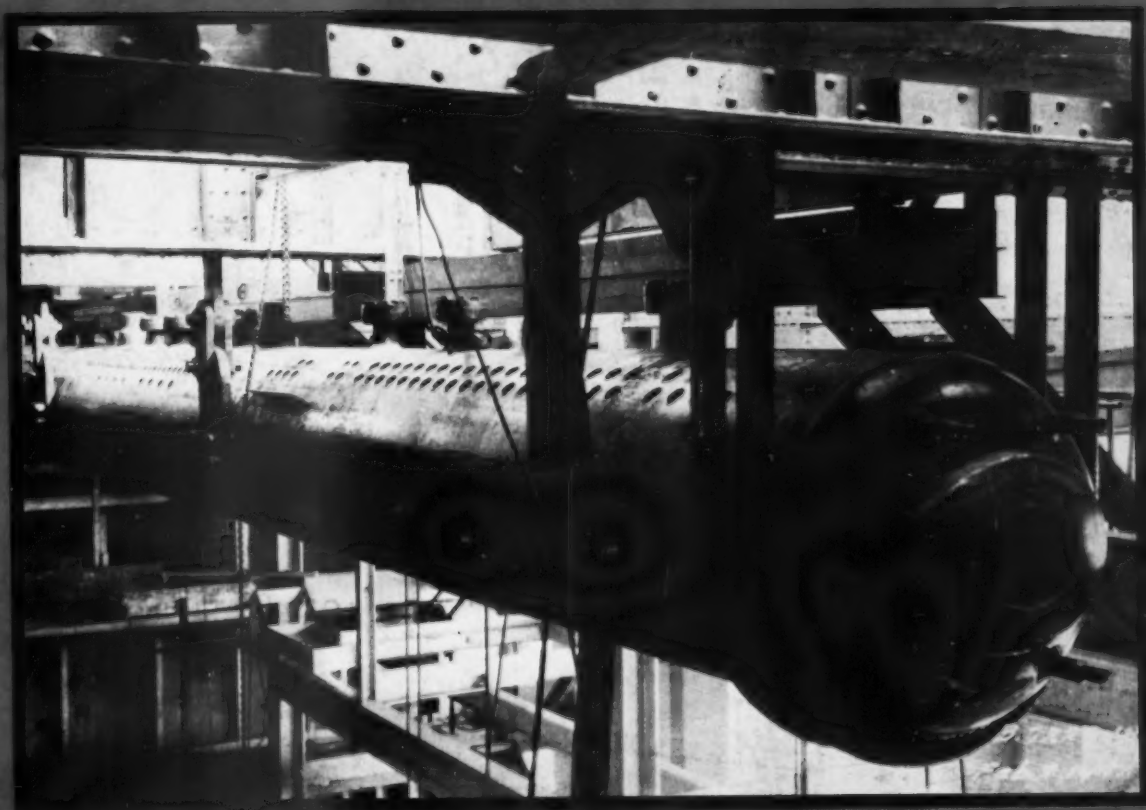


COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

September, 1942

SEP 26 1942



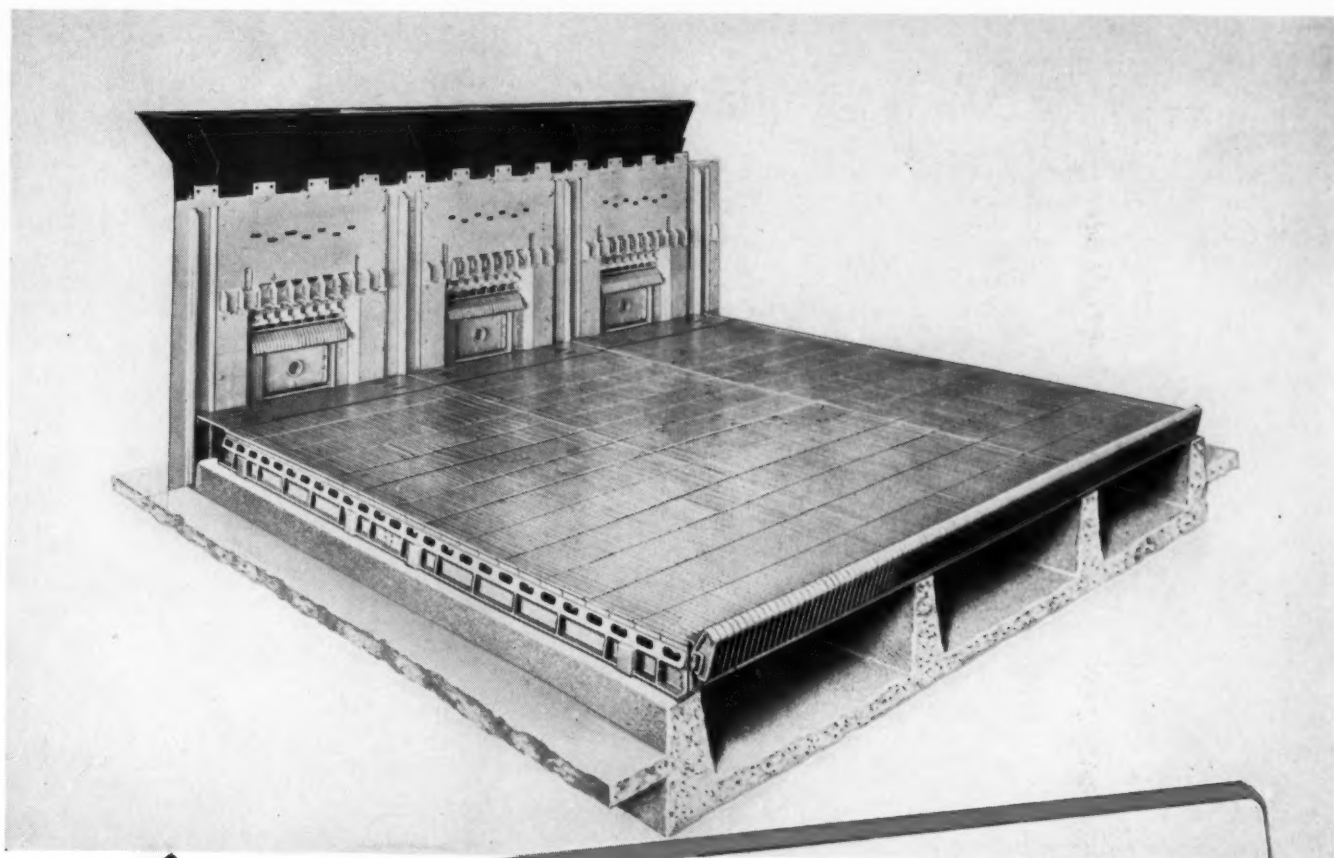
Suspension of 60 ft 10 in. drum of large steam generating unit

An Important TOPPING INSTALLATION ►

PHOSPHORIC ACID—A New Reagent

For Use With Hot-Process Water Softeners ►

Burning Midwestern Coals on Traveling Type Grates ►



✓ **ALL THE ADVANTAGES OF SPREADER FIRING**
 + **plus the added values of C-E stoker experience**

Present-day problems growing out of the war emergency have added new emphasis to the advantages of spreader stoker firing.

Because the spreader stoker burns a wider range of low cost coals than any other type of stoker, it is not limited by sources of fuel supply.

Because the spreader stoker, when equipped with adequate automatic control, is easier to operate than any other type of stoker, it is better suited to personnel problems of the present emergency.

Because the spreader stoker weighs less per lb of coal burning capacity than any other type of stoker, it

helps to conserve critical war materials.

In addition to these inherent advantages of spreader firing, the users of C-E Spreader Stokers get the benefits of Combustion Engineering's vast experience with all types of stokers. The practical results of this experience, in terms of advanced design features and sound construction, may be judged from the fact that it is based on the manufacture and installation of over 16,700 stokers serving an aggregate of nearly 5,000,000 boiler hp.

C-E Spreader Stokers have been applied to boilers of all types, with capacities ranging from 4,000 to 175,000 lb of steam per hr.

A-683

COMBUSTION  **ENGINEERING**

200 Madison Avenue

New York, New York

C-E PRODUCTS INCLUDE ALL TYPES OF GRILLS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME FOURTEEN

NUMBER THREE

CONTENTS

FOR SEPTEMBER 1942

FEATURE ARTICLES

An Important Topping Installation.....	36
Burning Midwestern Coals on Traveling Type Grates <i>by John Cruise</i>	42
Phosphoric Acid—A New Reagent for Use With Hot- Process Water Softeners <i>by C. E. Joos</i>	45
WPB Curtails Utility Projects.....	48
The Law of Patent Infringement <i>by Leo T. Parker</i>	51
Maritime Commission Makes Awards to Combustion Engineering Company.....	54

EDITORIALS

Fuel Conservation.....	35
Blackouts and Station Loads.....	35
Central Heating Prospects.....	35

DEPARTMENTS

Facts and Figures.....	49
Review of New Books.....	57
Advertisers in This Issue.....	60

H. STUART ACHESON,
Advertising Manager

ALFRED D. BLAKE,
Editor

THOMAS E. HANLEY,
Circulation Manager

Published monthly by COMBUSTION PUBLISHING COMPANY, INC., 200 Madison Avenue, New York
A SUBSIDIARY OF COMBUSTION ENGINEERING COMPANY, INC.

Frederic A. Schaff, President; Charles McDonough, Vice-President; H. H. Berry, Secretary and Treasurer.

COMBUSTION is sent gratis to engineers in charge of steam plants from 500 rated boiler horsepower up and to consulting and designing engineers in this field. To others the subscription rate, including postage, is \$2 in the United States, \$2.50 in Canada and Great Britain and \$3 in other countries. Single copies: 25 cents. Copyright, 1942 by Combustion Publishing Company, Inc. Issued the middle of the month of publication.

Publication office, 200 Madison Ave., New York **CCA** Member of the Controlled Circulation Audit, Inc.

Printed in U. S. A.

BE SURE YOU HAVE YOUR COPES EQUIPMENT DIRECTIONS HANDY

● In these hurried times we pause to suggest a little "ounce of prevention" assistance. Every COPES Regulator, Pump Governor, Differential Valve, Desuperheater, Reducing Valve is covered by a book of instructions for its care and maintenance. Changes in personnel calling for new men at vital power plant positions may also call for a new COPES Book to replace the original that may have been mislaid.

● We ask the thousands of COPES users to check carefully and to make sure they have COPES equipment instructions handy. ● Request on company letterhead, please.

Book 44B—
Operation of COPES
Flowmatic with Direct
Operated Valve

Book 30A—
Operation of COPES
BI Regulator

Book 43—
Operation of COPES
SL Pump Governor

Book 42—
Operation of COPES
3-S-2 Differential Valve

Book 34E—
Operation of COPES
OT Regulator

Book 46E—
Operation of COPES
Flowmatic with Relay
Operated Valve

Book 38C—
Operation of COPES
BI Regulator

Book 40B—
Operation of COPES
DA-2 Regulator

Book 31B—
Operation of COPES
SS Differential Valve

Book 33C—
Operation of COPES
D.S. Pump Governor

OVER
60,000
COPES
FEED WATER
REGULATORS
IN SERVICE

NORTHERN EQUIPMENT COMPANY • 926 Grove Drive, Erie, Pa.

Feed Water Regulators • Pump Governors • Differential Valves • Liquid Level Controls
Reducing Valves • Desuperheaters

BRANCH PLANTS IN CANADA, ENGLAND • REPRESENTATIVES EVERYWHERE

★ GET CLOSER LEVEL CONTROL WITH THE **FLOWMATIC**
★ REGULATOR

COPES FEEDS BOILER ACCORDING TO
STEAM FLOW-AUTOMATICALLY

EDITORIAL

Fuel Conservation

In the months ahead constant watchfulness and many expedients will be necessary to insure that available fuel supplies will meet all the demands of war production. To this end current literature in the power plant field is replete with information for operating men, showing how to meet heavy demands with existing equipment, reduce maintenance and maintain most efficient operation.

However, it is not sufficient that power men, alone, become fuel conscious; the idea must be impressed upon all production departments as well. Those responsible for the use of process steam can often effect substantial savings in cooperative scheduling of operations that will prevent sudden peak demands. Such demands tax capacity and make for lower efficiency in fuel utilization. Even the individual machine operator, if sold on the idea, may do his bit in saving power, and many such operators, collectively, can accomplish much. The same applies to illumination when not needed.

The time has arrived when the customary American habit of thinking in terms of "plenty" must give way to closer attention to the little savings as an aid to winning the war; and nowhere is this more important at present than in fuel conservation.

Blackouts and Station Loads

Many wonder as to what happens within the confines of a large power station when a citywide blackout alarm is sounded, and again when the "all-clear" signal is given. What is the effect of the sudden drop in load and its equally sudden resumption; and what proportion of the load is thus affected? One might envision the popping of safety valves, on the one hand, and decreased voltage, on the other; but apparently this does not happen.

Obviously, conditions will vary in different localities, but there are usually compensating factors that tend to lessen the effect. In some cases the drop in load may be comparable to that in an industrial community when the noon whistle blows; or in others, the increase may be similar to that imposed by a sudden thunder storm, particularly where the lighting load constitutes a major portion of the total.

In the first place, the "dim-out," as already practiced in many coastal and near-coastal cities, has substantially reduced that portion of the load which is directly affected by a blackout. Also, many war production plants that operate night shifts have provided for screening of skylights and windows so that operation may continue until advised that actual danger exists; and, to a lesser degree, this applies to some residential load. Furthermore, certain very essential establishments have been exempted from practice blackouts, and in special cases, where power is furnished to underground transit

lines, they continue to operate. These several factors, collectively, usually account for a considerable load that is unaffected by a blackout.

Where a city is served by several power stations, it is customary to let the most economical plant, or plants, carry the base load and have some other plant take the swings and handle system regulation, this often being handled by certain units within the plant. Thus it is the latter that is most likely to be affected by a blackout. Furthermore, where interconnection exists with outside systems, and this is now quite general, it is possible for such systems to take up some of the slack.

Boiler plants fired with pulverized coal or oil are likely to be more flexible in handling rapid swings in load than those fired by large stokers, the fuel beds of which represent a vast amount of stored-up heat even though the fans have been shut off. However, the extensive use and proved performance of automatic control on various equipment has further simplified the problem.

Finally, the operating personnel of electric utilities have been carefully trained in the handling of such situations to the end that minimum disturbance may result; all of which would indicate that a blackout has less effect than one might assume offhand.

Central Heating Prospects

That the present fuel oil situation in the East threatens the heating of numerous city apartment houses, with the advent of cold weather, is a matter of considerable concern to local authorities. In fact, this was responsible for the American Society of Heating and Ventilating Engineers having initiated a "War on Fuel Waste Week," August 17-22, which was marked by a Forum in New York on August 17, in which numerous speakers, including Mayor LaGuardia, participated.

As in the case of individual residences, the application of fuel oil burning to apartment houses and office buildings has spread greatly during recent years. While many of these are being converted to coal burning through the installation of stokers, others, where conveniently located, will find a solution in the adoption of central steam supply, which is another way of converting to coal.

A number of the larger cities in the North Atlantic States have central heating systems, but the high initial investment in distribution facilities has usually restricted the areas served. It is not likely that it will be possible, under present conditions, to extend these systems appreciably; but it is anticipated that the number of service connections within those areas will be greatly increased—or to the extent of the materials available and priorities attainable.

Therefore, it is reasonable to expect that the coming winter will mark a new high in the steam demands on such systems and perhaps reverse the aspect of what has long generally been considered a more or less unprofitable industry.

An Important TOPPING INSTALLATION

This topping installation consists of a 50,000-kw turbine-generator taking steam at 1250 lb, 925 F from three 425,000-lb per hour boilers and exhausting to three older low-pressure turbines. This extension, when all steam is supplied by the new high-pressure boilers, is expected to reduce the station heat rate from 23,000 to 12,500 Btu per kw-hr and to furnish 140,000 kw capacity from this source. For obvious reasons which exist at the present time, it is not deemed expedient to reveal the identity of this station.

THE second step in a modernization and expansion program, initiated in 1937 by one of the country's large utilities with the installation of its first topping unit at one of its older stations, was completed when the new 50,000-kw high-pressure turbine-generator unit at the station under description was placed in service in January 1942. Prior to the completion of this second topping unit, its three high-pressure boilers were placed

in operation during 1941. As the boilers were ready for operation before the turbine, they were employed to supply high-pressure steam to the low-pressure turbines in the station through pressure-reducing bypass valves. Advantage was taken of this preliminary operation of the boilers to determine their operating characteristics and to make required adjustments; it also afforded the plant operating personnel an opportunity to put into practice the training received in an instruction program completed before the boilers were ready for service. The erection of the turbine-generator unit was not completed until December 1941, and it was initially put on the system January 1942. It has since carried full load of 50,000 kw and is in regular service at the present time.

This station was selected for the addition because it represented the logical point in the system where maximum benefits could be obtained from added capacity and efficient generation. The decision to superpose rather than install a condensing turbine was influenced by the limited supply of condensing water and the economic advantages offered by the replacement plan.

The design of this plant extension was dictated to a considerable extent by existing features of the station and also by valuable operating experience gained from

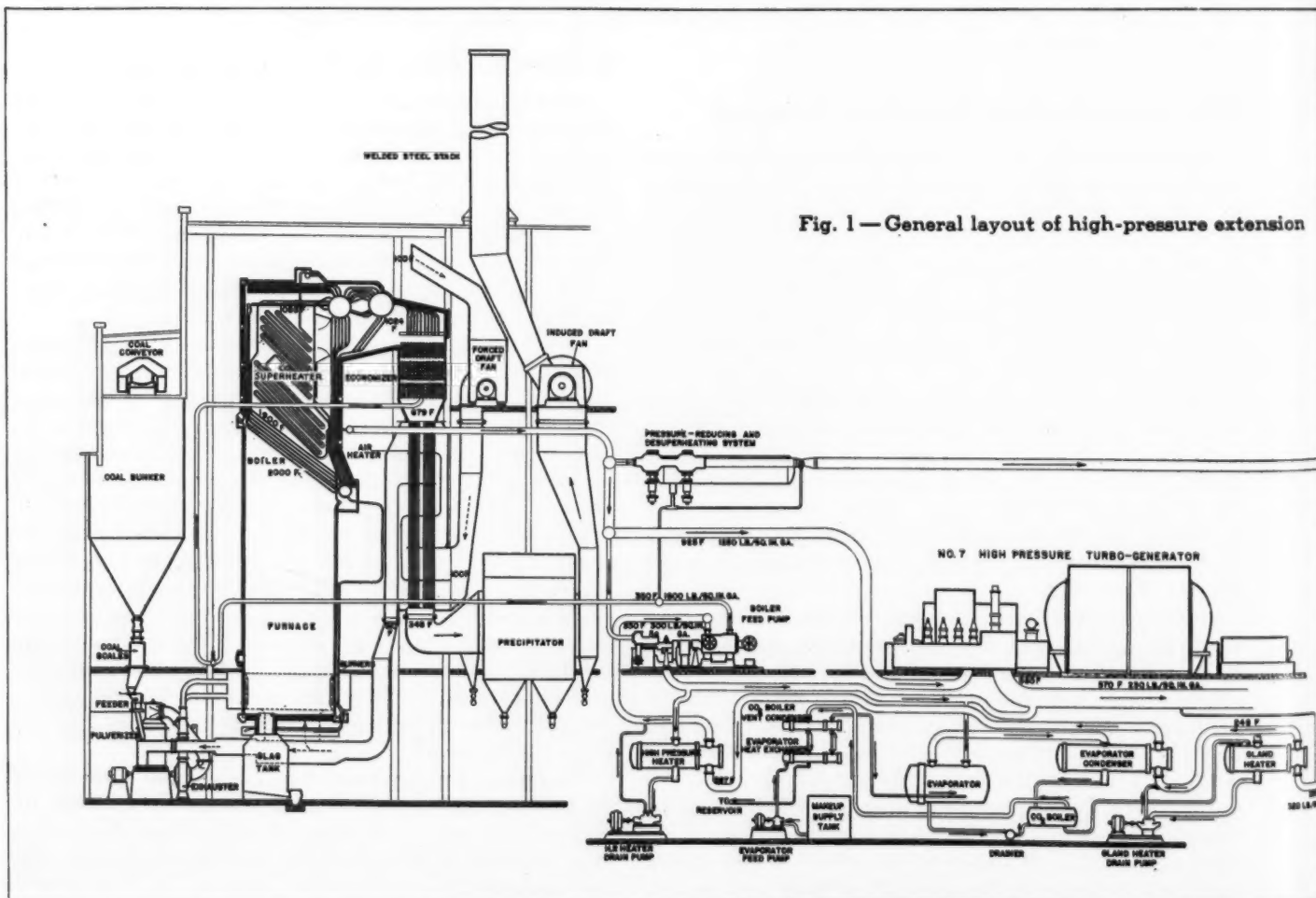


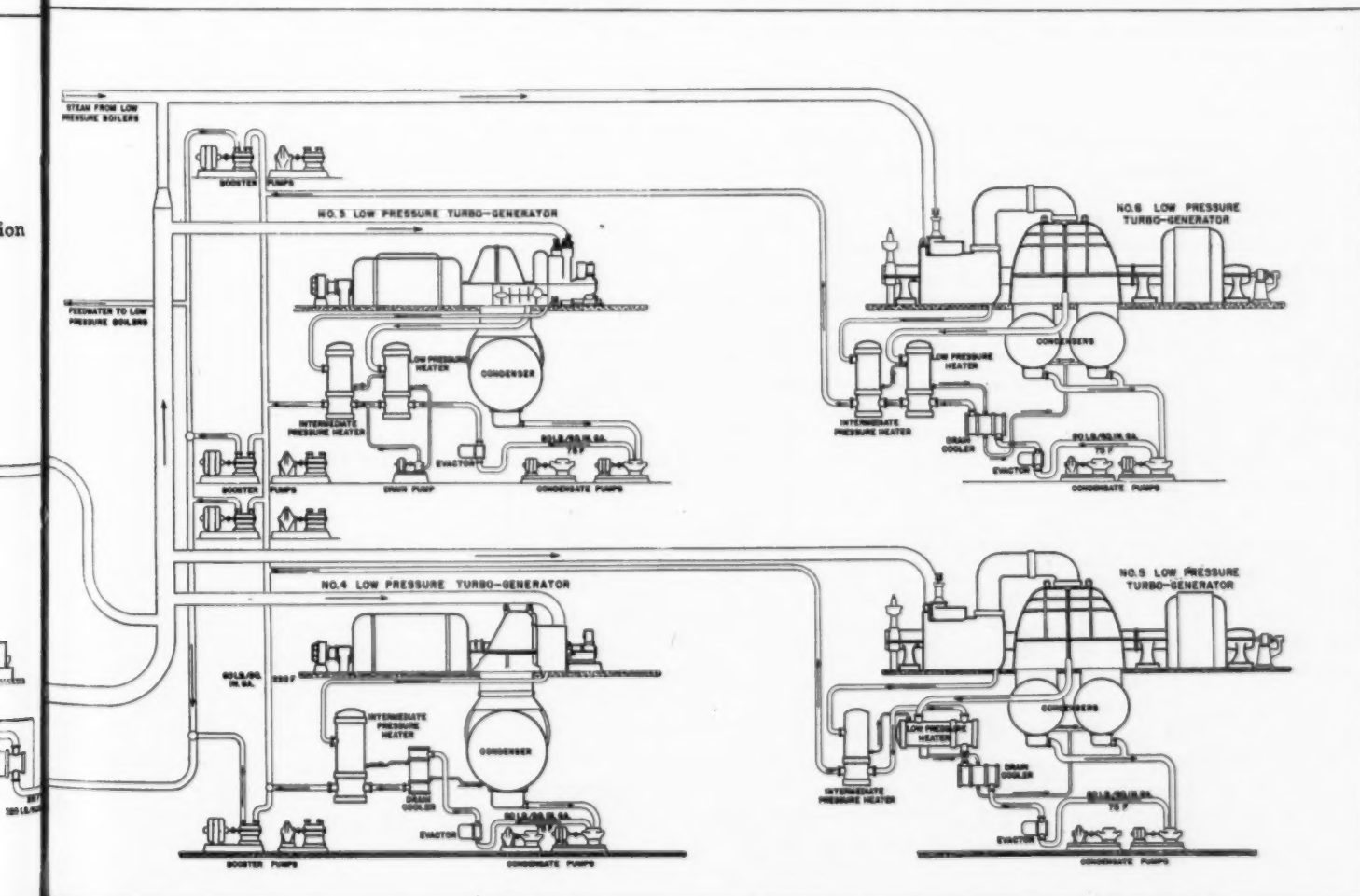
Fig. 1 — General layout of high-pressure extension

the earlier topping unit at the first station mentioned. Existing plant conditions were primary factors in determining the size of the turbine, the number of steam generating units, the steam conditions and general layout. Particular attention was given to improvements in the boiler plant, which would eliminate operating difficulties previously encountered at the other plant. Wide spacing in tube banks and liberal furnace proportions with a low heat release rate at maximum rating were provided to reduce difficulties previously experienced from slagging. As a result of adequate and effective boiler water circulation and application of the method of feedwater treatment that had been found satisfactory with the other high-pressure installation, no tube failures have occurred up to the present time. The major problem of combating slag-fouling of the boiler and superheater tube surfaces, encountered in previous installations when burning coal of approximately 10,000 Btu per lb, has dwindled in this installation to one of relatively minor concern.

Three bent-tube type high-pressure boilers together with the necessary auxiliaries and control systems were installed (see Fig. 1 and Table of Equipment). Each is capable of delivering 425,000 lb of steam per hr at 1325 lb per sq in. and 935 F. These boilers serve a combined impulse- and reaction-type single-cylinder turbine driving a 62,500-kva, 80 per cent P.F., 3600-rpm hydrogen-cooled generator. The turbine operates with 1250 lb per sq in., 925 F steam at the throttle and exhausts at 230 lb, 580 F to the low-pressure header system.

The topping turbine will normally operate in combination with three of four existing horizontal low-pressure condensing turbines, two of which are 25 cycle and two 60 cycle. While the aggregate capacity of the four low-pressure turbines is 125,000 kw, only about 90,000 kw of this capacity can be served with steam exhausted from the topping unit installation, so that when the load of the high-pressure turbine is 50,000 kw the combined capacity of the high-pressure plant will be about 140,000 kw. These low-pressure turbines are considered as part of the high-pressure plant for at different periods of the day they will operate with topping unit steam, depending on the demand of the system for 25- or 60-cycle generation or both. Full capacity of all low-pressure equipment including that of the two low-pressure vertical units can be operated simultaneously if the remaining fifteen low-pressure boilers are operated.

Like many other topping units, existing building and general facilities are utilized to their fullest extent. Removal of old equipment permitted an arrangement which is rather unique. The piping system of this installation is relatively simple and the arrangement of equipment is such that ample room, accessibility and ventilation are provided for. The new boilers occupy the same floor space as was used for boilers formerly supplying three turbine-generator units. In this connection it is interesting to note that the steam generating capacity was increased from an equivalent of 70,000 kw to approximately 140,000 kw. While the greater height of the new boilers required the raising of the boiler-room roof, the



addition of the new turbine necessitated only minor changes in the turbine room.

Heat Balance

All four of the horizontal low-pressure turbines operate on the regenerative cycle. Condensate from these turbines (see flow diagram, Fig. 2) is pumped from condenser hotwells through steam-jet air-evactor condensers, low-pressure and intermediate heaters to the suction of the booster pumps (not indicated on Fig. 2). These pumps, operating in parallel, discharge feedwater through the gland heater, evaporator-condenser and high-pressure heater to the suction of the high-pressure boiler feed pumps which deliver the water through feedwater regulators to the economizers of the high-pressure boilers at approximately 350 F. Under normal operating conditions the steam makeup of the high-pressure plant is evaporated raw water with the exception of that portion representing condenser leakage. Raw water from the makeup supply tank, fed by city water, is pumped through an evaporator heat exchanger, a CO₂ boiler vent condenser and then is fed to the evaporators. Heat for evaporation is obtained from evaporator coils which are supplied with steam taken from the topping unit exhaust.

Steam Generating Units

Each steam generating unit consists of a three-drum, bent-tube boiler and water-cooled furnace. The general design is typical of the trend followed in the development of recent high-pressure steam generators. As previously mentioned, particular attention was given to provisions for preventing slag fouling of the boiler tube

banks and superheater surfaces. In addition to the mechanical flue-blowing installation on each unit, facilities have been provided for hand lancing all boiler and superheater surfaces, very little of which has been necessary to date. Furthermore, the problem of adequate and effective boiler water circulation was carefully studied. Particular stress was placed on the matter of solid-water downcomer supply and ample return-circulating-tube area. Provisions to secure single-circuit, positive circulation have proved adequate as no tube failures have occurred in the installation. Each unit is equipped with a plain tube economizer and a tubular type air preheater and has bypass damper control for the superheat. The upper drums are 54 and 60 in. diameter and the bottom drum 30 in.

Coal Handling and Pulverizer Equipment

Coal for the high-pressure boilers is unloaded from barges or rail cars, crushed to 1 1/4 in. size and delivered to the bunkers by means of bucket conveyors and new belt conveyors. One 750-ton, split-discharge bunker is provided for each boiler. The 350 tons per hour capacity of the coal-conveying system transports a 24-hr supply in approximately 5 hr. Coal from the bunkers passes through automatic coal scales to the feeders and mills. There are two scales, two feeders and two 17.5-ton per hr bowl-type mills per boiler. After pulverization, coal conveyed by primary air passes through the exhausters and is discharged into the furnace through two sets of tangential burners located, one above the other, in the lower corners of the furnace. Each mill furnishes coal to one set of four tangential burners

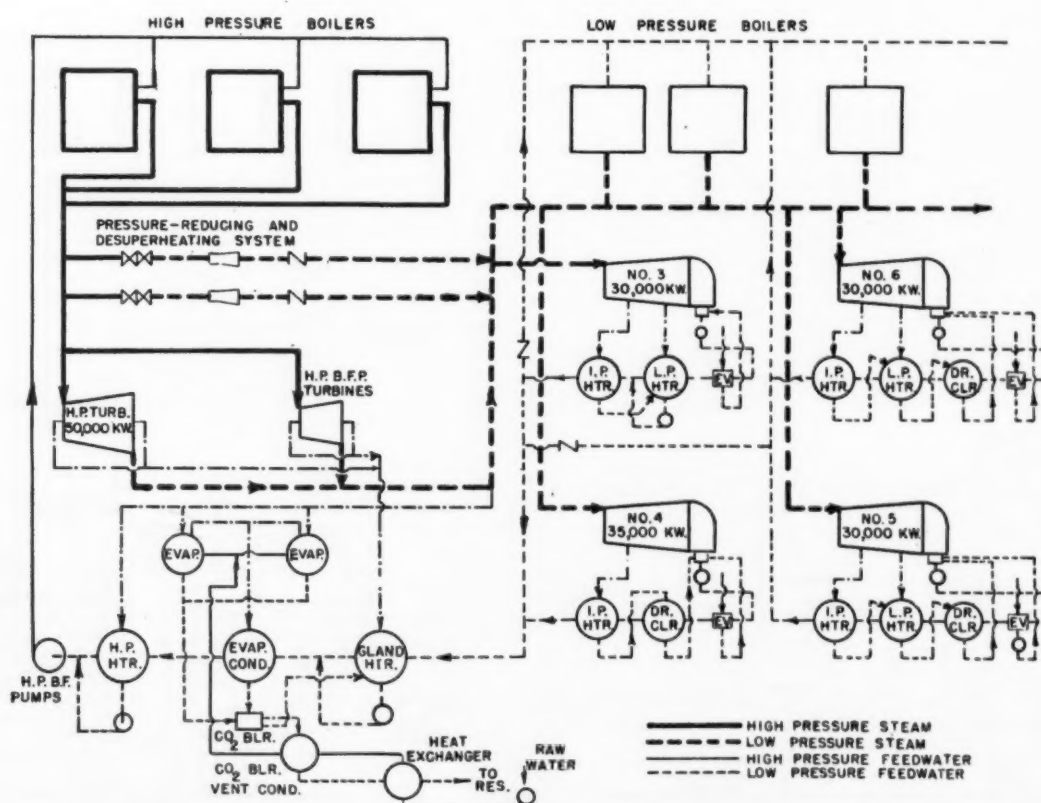


Fig. 2—Flow diagram for high and low-pressure steam and feedwater

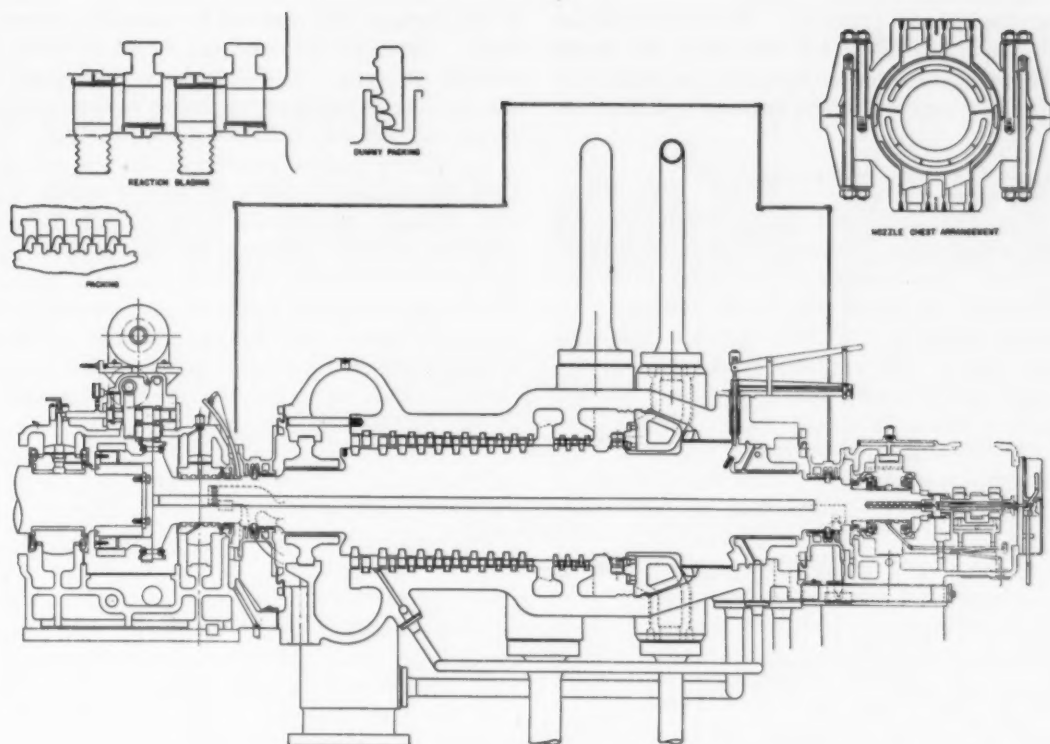


Fig. 3—Cross-section of topping turbine

Electrical Precipitators

The fuel fired in the new high-pressure steam generating units has a high ash content of approximately 14 per cent. It is pulverized to a fineness such that 70 per cent will pass through a 200-mesh screen. The precipitators, one for each boiler, are located in the gas ducts between the air heater outlet and induced-draft fan inlet and remove 90 per cent of the fly ash from the flue gas.

Fly Ash and Furnace Slag

Fly ash collected in the precipitator hoppers is removed periodically by means of a conveyor system which discharges the ash into a storage tank from where it is passed through a dustless unloader for disposal. Removal of the fly ash from all hoppers of one precipitator is made simultaneously. The flow of air in the conveyor system is induced by a positive displacement mechanical exhaustor. A standby steam-jet exhaustor is provided for emergency.

Melted ash (furnace slag) flows continuously from the furnace walls through a water-cooled slag hole in the furnace floor into a water-filled slag tank located below each furnace from which it is periodically sluiced to an outside ashpit for disposal.

Boiler Control System

The combustion control system is designed to provide three methods of control, namely, full automatic control, boiler manual control and hand control. Under full automatic control the system is actuated by changes in the main steam header pressure through a master pressure element controlling the regulators of all three boilers. With boiler manual control, the regulators of

any boiler may be controlled by a single manual control element; whereas under hand control the regulators of each boiler may be controlled individually from the boiler board when desired. A superheater bypass damper regulator for maintaining a constant steam temperature is controlled by a remote hand-control unit only.

Fuel feed is controlled through regulators on the mill feeder and primary air by regulators operating exhaustor inlet dampers. The total air flow is controlled by regulators which position vanes on the induced-draft fans.

Furnace draft is handled automatically by regulators which receive impulses from the furnace pressure and position control vanes in the forced-draft fan suction. These regulators can also be controlled manually from boiler boards. The boiler water level may be maintained automatically or regulated by hand from the boiler board. Efforts to attain simplicity in the control system have resulted in a design which has many advantages over the system used for the earlier installation.

Boiler Feed Pumps

Normally three boiler feed pumps are used when the three boilers are in service. Of the four high-pressure boiler feed pumps provided three are turbine-driven and one is motor-driven. The feed pump turbines take steam from the high-pressure steam supply and exhaust to the low-pressure header system in parallel with the topping turbine. The turbine-driven pumps are equipped with a feedwater differential control system that is designed to maintain an equal (or proportioned, if desired) flow of water through each turbine-driven pump and at the same time maintain a pressure differential between steam and feedwater pressure that is constant or that may be set to increase with increased boiler load. This control is accomplished by automatically regulating the steam

supply to the feed-pump turbines. The motor-driven feed pump is hand controlled by throttling the pump discharge. All turbine-driven pumps may be hand controlled if desired by regulating the turbine speed governor.

High-Pressure Turbine-Generator

Fig. 3 is a cross-section of the topping turbine which is of the Rateau reaction type. Because of the large amount of steam involved, the turbine is provided with two steam chests located on either side of the cylinder. On each steam chest is mounted a 14-in. throttle valve and four admission valves. An equalizing pipe is provided which connects the two steam chests at points directly after the throttle valves. The purpose of this pipe is to equalize the flow through both throttle valves at high loads. The turbine is designed for four valve points, a pair of valves controlling the steam flow for each valve point.

As indicated, the steam expands through one Rateau (single impulse stage) and thirteen reaction stages. The impulse blades are of extremely sturdy design so as to safely withstand shock loading encountered under partial load admission. The turbine is equipped with both speed and back-pressure governors.

The generator is a 50,000-kw, 80 per cent power factor, three-phase, 60-cycle, 12,600-volt, 3600-rpm, hydrogen-cooled unit. It is excited by means of an air-cooled exciter and pilot exciter driven from the main shaft through a 2:1 reduction gear which reduces the speed to 1800 rpm. The generator is connected through reactors to the 12-kv, 60-cycle main buses.

Pressure-Reducing and Desuperheating Systems

The pressure-reducing and desuperheating equipment is provided to permit continued operation of the low-pressure turbines with steam from the high-pressure boilers in the event of outage or trip-out of the topping turbine. Two sets are required because of valve size limitations in practical operation. Each set, capable of passing 700,000 lb of high-pressure steam per hour, consists essentially of a quick-opening and a regulating valve in series, followed by a desuperheating venturi at the throat of which desuperheating water is injected. When the pressure in the low-pressure header reaches a predetermined low value this equipment automatically cuts in and steam supply to the low-pressure system is regulated. For use during periods when automatic control is not desired, remote hand controls for positioning the regulating valves are provided.

Preliminary Operating Experience

As previously mentioned, operation of the installation to date has shown that few changes were necessary in the original installation to secure desired operating characteristics. Some corrective measures were required, however, to secure the degree of superheat control necessary to satisfy the rather rigid specified requirements of the turbine manufacturer. It was found that minor changes were required in the superheater gas bypass damper arrangement to provide greater gas flow through the bypass when operating at high capacities. It was also found that the slag covering the side-wall tube surfaces would drop off when changing from the higher to lower boiler ratings. This caused greater heat absorption

in the furnace and resulted in excessive changes in superheat. The application of slag hooks (tube studs) up to a certain coverage of the furnace wall area retained a normal slag coating at all boiler ratings and resulted in more uniform superheat control.

To secure desired superheat over a greater range of operating capacity the top set of burners on one boiler was replaced with burners of the tilting type. These are manipulated to direct the flame upward when the boilers are operated at lower ratings, the result being that proportionately less heat is absorbed by the furnace walls and more by the superheater. Tilting burners will be applied to all the boilers as conditions permit.

In general, no major design changes were necessary in the installation. With the minor modifications mentioned above, it is anticipated that the new high-pressure installation at this station will take its place among highly efficient topping units.

The station heat rate in previous years of normal low-pressure operation was about 23,000 Btu per net kw-hr. The high-pressure addition will result in a performance of about 12,500 Btu per net kw-hr with only the high-pressure boilers in operation. At maximum station load, with low-pressure boilers also in service, it is estimated that the overall station heat rate will be about 14,000 Btu per net kw-hr. Although no normal overall performance values of the complete high-pressure plant are as yet available, the topping turbine having been in service only a short time, present early indications are that predicted economy will be achieved.

Details of Principal Equipment

HIGH-PRESSURE TURBINE-GENERATOR

One 50,000-kw, 3600-rpm turbine, 1250 lb per sq in., 925 F at throttle, 230 lb per sq in. exhaust, 1 impulse—13 reaction stages.
One 50,000-kw, 3600-rpm generator, 12,600 v, 3-phase, 60-cycle, 80 per cent P.F. hydrogen-cooled

HIGH-PRESSURE BOILERS

Three 425,000 lb per hr, 1325-lb per sq in. pressure 935 F steam generators
Effective heating surfaces:
Boiler 10,550 sq ft
Furnace 6,815 " "
Superheater 22,884 " "
Economizer 12,262 " "
Air heater 62,725 " "
Furnace volume 24,250 cu ft
Max. heat release 23,000 Btu per cu ft per hr
Six 17.5 ton per hr bowl mills

FANS

Three 240,000-cfm turbovane induced-draft fans. Motors, 3-600 hp, 720-rpm, 3-1000 hp, 900 rpm
Three 145,000 cfm turbovane forced-draft fans. Motors, 3-250 hp, 900-rpm, 3-500 hp, 1200 rpm

ELECTRICAL PRECIPITATORS

Three 75-kv, 36-gas duct precipitators
Six 25-kva, 208-v, 75-kv transformers
Six mechanical rectifiers

BOILER FEED PUMPS

Three 500,000-lb per hr, 1600-lb per sq in., 350-F pumps
Three 1250-hp, 3560-rpm turbines
One 500,000 lb per hr, 1600-lb per sq in., 350-F pump
One 1500-hp, 3560-rpm constant-speed motor

FEEDWATER HEATING AND EVAPORATOR EQUIPMENT

One 2230-sq ft, 2-pass gland heater
One 1408-sq ft, 2-pass high-pressure heater
One 3000-sq ft, 2-pass evaporator condenser
Two 25,000-lb per hr, 910-sq ft evaporators
One 101,600 lb per hr, 36-in. dia. CO₂ boiler
One 111 sq ft, 2-pass CO₂ boiler vent condenser
One 75.5 sq ft, single-pass evaporator heat exchanger

PUMPS

Two 250-gpm, 345-lb per sq in. high-pressure heater drain pumps
Two 350-gpm, 345-lb per sq in. gland heater drain pumps
Two 150-gpm, 180-lb per sq in. evaporator feed pumps

PRESSURE-REDUCING AND DESUPERHEATING EQUIPMENT

Two 1500-lb, 10-in. quick-opening valves
Two 1500-lb, 10-in. X 16-in., 700,000-lb per hr pressure-reducing valves
Two 400-lb, 16-in. X 18-in., Venturi-type desuperheaters
Two 400-lb, 18-ft X 42-in. dia. water-storage tanks

TO EXECUTIVES: NOW YOU CAN HELP

Even More...

**New Treasury Ruling Permits Purchases
UP TO \$100,000, in any Calendar Year, of
Series F and G WAR BONDS!**



The Treasury's decision to increase the limitations on the F and G Bonds resulted from numerous requests by purchasers who asked the opportunity to put more money into the war program.

This is not a new Bond issue and not a new series of War Bonds. Thousands of individuals, corporations, labor unions, and other organizations have this year already purchased \$50,000 of Series F and G Bonds, the old limit. Under the new regulations, however, these Bond holders will be permitted to make additional purchases of \$50,000 in the remaining months of the year. The new limitation on holdings of \$100,000 in any one calendar year in either Series F or G, or in both series combined, is on the cost price, not on the maturity value.

Series F and G Bonds are intended primarily for larger investors and may be registered in the names of fiduciaries, corporations, labor unions and other groups, as well as in the names of individuals.

The Series F Bond is a 12-year appreciation Bond, issued on a discount basis at 74 percent of maturity value. If held to maturity, 12 years from the date of issue, the Bond draws interest equivalent to 2.53 percent a year; computed on the purchase price, compounded semiannually.

The Series G Bond is a 12-year current income Bond issued at par, and draws interest of 2.5 percent a year, paid semiannually by Treasury check.

Don't delay—your "fighting dollars" are needed *now*. Your bank or post office has full details.



Save With . . .

War Savings Bonds

This space is a contribution to America's All-Out War Program by COMBUSTION

Burning Midwestern Coals on Traveling Type Grates

Some observations on the design of furnace and arrangement for air admission best adapted to the burning of coals with mildly caking characteristics on stokers of the traveling grate type. The influence of arches on the rate of ignition penetration and maintenance of proper grate temperature are also discussed.

NUMEROUS articles and papers have been written concerning the type of furnace best adapted to the burning of midwestern coals when fired on the traveling grate type of stoker, and the opinions which have been expressed are about as numerous as the articles presented. However, knowledge has been gained from all the ideas advanced and it is in the same spirit that the following thoughts are given.

First, in the design of any furnace, knowledge of the fuel is essential both as to its chemical characteristics and its physical behavior when burning. Of special interest is the caking behavior of the particular fuel, as coals with a high degree of caking are seldom handled successfully on these grates. Nevertheless, many midwestern coals having caking tendencies to some degree are successfully burned on such stokers by applying methods that have developed with years of experience and through the application of principles discovered in the research laboratories.

Ingredients That Affect Caking

These methods materialized as knowledge of some of the causes of caking became known and as one began to appreciate the fact that coals from the same field and having similar analyses varied widely in burning characteristics. This fact was ably brought out in the March 1938 issue of *Mechanical Engineering* where the author discussed Illinois coal from the viewpoint of four inherent components and described in detail its characteristics. Briefly stated, the four ingredients are known as clarain, vitrain, durain and fusain, which may be identified as follows:

Clarain is a glossy, finely laminated ingredient that swells to some extent when heated and has a tendency to "finger." Vitrain is a brilliant jet black substance and shows the greatest expansion when heated. Durain is the dull laminated grayish component which has poor agglutinating qualities and the particles have practically no coherence. Fusain is known as the mineral charcoal and lacks swelling and agglutinatory characteristics, and in combination with the other ingredients reduces their tendency to swell.

In this same article it is pointed out that another peculiar behavior of these ingredients is that they will

concentrate in the order of their breakage characteristics. That is, for any given screen size one of these ingredients will predominate. This probably explains why some screen sizes are troublesome when burning. However, this is a coal preparation problem and is beyond the control of the furnace designer. It is referred to only because of its effect on furnace operation.

A further fact uncovered was that the weathering of coals will partially destroy the caking characteristics and an application of this principle in the firing technique was investigated and reported upon in a recent A.S.M.E. paper¹ by S. Wilson Guthrie. The conclusion drawn from this investigation was that if air is introduced below the point of ignition while the temperature of the coal is increasing, a condition of rapid weathering is accomplished and sufficient oxidation takes place to decrease the amount of coke-tree formation. This condition shows the necessity of providing for early admission of undergrate air in quantity when laying out the design of the furnace.

Last but not least in the effort to avoid excessive caking, the subject of proper tempering of coals with moisture plays an important rôle in the success or failure of an otherwise well-designed installation. It is essential that as the temperature of the coal particle rises, the flow of volatile gases from the interior of the particle should be rapid and uninterrupted. Fissures in the coal, caused by rapidly expanding steam formed from the moisture, permit this to take place and distillation from the whole particle is more uniform. The danger of breakdown of the distillate into complex tarry compounds is thus greatly reduced and the difficulty of burning the less complex hydrocarbons is lessened.

The foregoing points to a condition in which air in large quantities must be passed through the fuel bed almost as soon as the fuel enters the furnace. To be able to meet this condition, ignition must be prompt and ignition penetration rapid, and combustion of the volatile gases must take place immediately. Such a condition is never fully achieved, however, and it therefore becomes necessary to supply additional air over the fire to complete the reaction. The quantity of over-fire air necessary might be considered as a measure of the inefficiency of the particular furnace design and its ability to perform properly.

Thus far the question of furnace design, as related to the successful burning of coal only, has been considered. Another factor that must be given attention is the possibility of overheating the grates in their passage through

¹ "Domestic Stoker for Bituminous Coal," by S. Wilson Guthrie, Research Engineer, Rochester & Pittsburgh Coal Company, presented at the Semi-Annual Meeting, Cleveland, O., June 8-10, 1942.

the furnace. Strangely enough, this is also a matter of furnace design, because by the proper application of air flow through the grate and at the critical point of the grate the temperature of the links or keys is quickly reduced below the danger point, but held there only as long as air flow through the grate continues. Bearing in

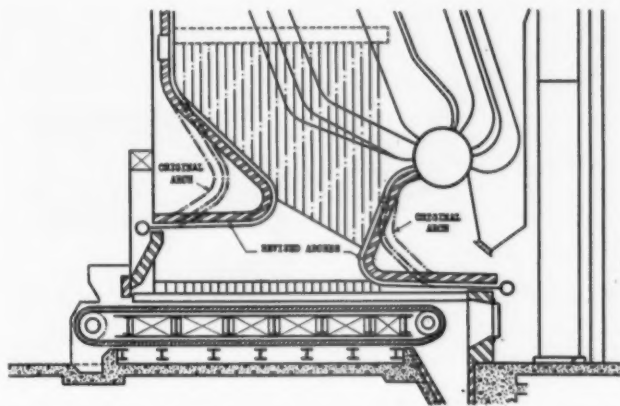


Fig. 1—Original contour shown dotted, rebuilt arches solid

mind that the maximum temperature of the grate usually occurs only a few feet from the end of the fire, which may be several feet from the end of the stoker, any air admitted and not gainfully used in the process of combustion will appear as excess air in the gas stream. It then becomes a function of the furnace to deflect this air into the gas stream in order that an excess air condition may be avoided.

A typical case which was described in a paper² at the A.S.M.E. meeting held at Kansas City, June 1941, will illustrate some of the points here discussed. This installation was designed to burn lignite (not a caking coal) but the data is complete enough to bring out some interesting points relative to the rapidity of ignition and ignition penetration which is one of the factors being discussed. This job was originally installed with a minimum of arches (see sketch, Fig. 1) and from information available it appears that ignition was never



Fig. 2—Sketch indicating the ignition and burning zone on a traveling grate
(Not in Gilg paper)

very satisfactory. The temperature of the chain was measured in its progress through the furnace and served as an indication of the rate at which ignition penetrated the depth of the fuel bed. With this type of firing, ignition takes place on the top surface of the fuel bed and works downward as the fuel bed moves toward the rear.

² "Some Recent Chain-Grate Stoker Installations," by F. X. Gilg.

When ignition reaches the bottom layer of fuel there is a sharp rise in the grate surface temperature. The zone of ignition and that of the burning coal is indicated in Fig. 2.

It is evident that with the revamping of the furnace and the installation of arches the ignition rate and its penetration became rapid (see Fig. 3), the fire ending at about the fourth compartment where the curve takes an upward turn. This upward turn of the curve gives evidence of reduced air flow. Subsequent experiments in which the air blast was delayed overcame the problem of hot grates, but fortunately in this case caking coal was not a factor with which to contend. It does serve, however, to indicate that air flow through the rear end of the grate beyond the point at which combustion is complete is essential to good operation when measured in terms of maintenance. One method for deflecting this air into useful channels is to employ a rear arch as the simplest means of achieving this result; it is one way of adding over-fire air that serves a double purpose.

This statement might seem to conflict with the previous observation that over-fire air might be credited as being a measure of furnace design inefficiency, but ex-

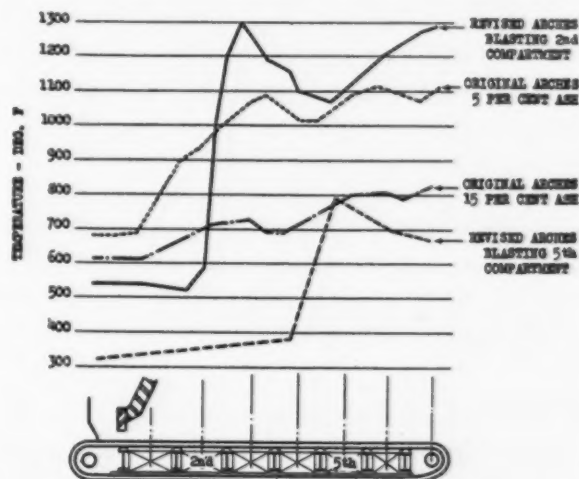


Fig. 3—Chart indicating grate temperatures with original and rebuilt arches

perience teaches that for various reasons it has never been possible to attain the ultimate in furnace design. Even in the best designs of today, over-fire air is still being supplied in addition to that admitted through the grates.

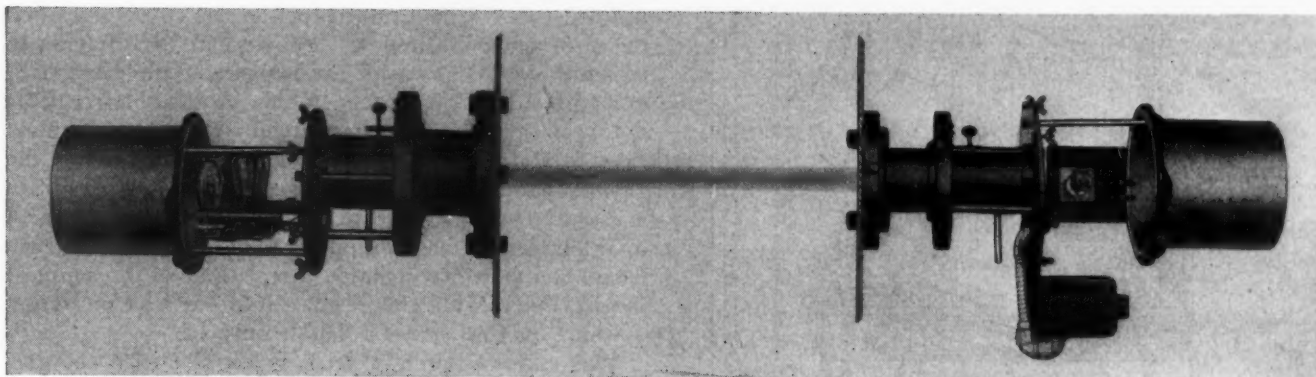
Conclusions

In conclusion, it appears that a well-designed furnace for burning midwestern coals on chain- or traveling-grate stokers should consist of:

1. A front covering arch to promote rapid ignition, to permit the introduction of the major air flow early, and to avoid serious caking and excessive breakdown of hydrocarbons.
2. A rear deflecting arch to utilize the grate cooling air as a form of over-fire air.
3. The combination of these two arches arranged to attain the maximum in mixing the air and gas streams.

THE ELECTRIC EYE SYSTEM

of automatic combustion control



... IS THE MOST ACCURATE system of boiler combustion control manufactured ... regardless of price. This is a Strong Statement, but it is the truth. The Electric Eye responds instantly to the change in flue gas color which occurs when a fractional per cent change in CO_2 content takes place; and causes corrective action, at the same time providing precisely regulated throttling and reset compensation to prevent hunting.

Incredibly Simple—Convincingly Efficient

To engineers accustomed to relatively complicated control systems, the Electric Eye control equipment seems incredibly simple. It is, however, highly efficient.

Nothing to Clog

There is nothing to clog. No flue gas piping. No flue gas cells. No stuffing boxes. No pilot valve.

Practically No Maintenance Trouble or Expense

Because of its simplicity and freedom from trouble-making factors, there is practically no maintenance; merely wipe off the "eye" periodically. Once installed there is nothing to clog, nothing to replace.

Always on the Job

Because there are no delicate moving parts to interrupt service, the Electric Eye System is always on the job.

Easy to Use—No Training Troubles

Fuel feed control direct from steam pressure, and air control from color of smoke follow the same principle as manual control, and are, therefore, easily understood by the operators. Because there are a minimum of moving parts the control runs normally without attention or adjustment maintaining efficient operation throughout the entire load range.

Same Equipment Can Be Used for Pulverized Coal or Oil

This is doubly important in these times of uncertain fuel supply.

INVESTIGATE THESE CLAIMS

Every one of these claims will be supported to your complete satisfaction. AND YOU CAN GET EARLY DELIVERY AND QUICK INSTALLATION. Every installation is supervised and *fully guaranteed* by a thoroughly competent and responsible engineering organization which for twenty years has specialized in combustion control equipment.



← SEND FOR YOUR COPY

BROOKE ENGINEERING CO., INC.

1517 Wayne Avenue • Philadelphia, Pa.

MANUFACTURERS OF THE FIRST SUCCESSFUL ELECTRIC EYE SYSTEM OF COMBUSTION CONTROL

PHOSPHORIC ACID—

A New Reagent For Use With Hot-Process Water Softeners

By using phosphoric acid with the hot process, it is possible to effect close control of the alkalinity and maintain it at low value; and, at the same time the cost of treatment is considerably less than that with other commonly used reagents.

By C. E. Joos
Cochrane Corporation

THE treatment of feedwater for high-pressure boilers by phosphate fed externally to the boiler has been previously described by the writer.¹ This method, applied either in a single stage or in two stages of treatment in a hot-process softener, has received wide application and is now being used for preparing feedwater for boilers operating at pressures up to 1400 lb per sq in. The continuous reduction of hardness in the effluent to the very low degree possible with this treatment is of special interest to engineers, since it results in almost entire absence of sludge accumulation, which is highly detrimental in boilers operating at pressures above 1000 lb per sq in. Fig. 1 compares the clarity of distilled water with that of concentrated boiler water taken from a plant with boilers operating at 400 lb per sq in. where this treatment was used. The sample on the left is the boiler concentrate after 1220 hr of steaming and that on the right is the distilled water. It will be noted that the sample on the left is entirely free of sludge, and inspection of the boilers indicates no deposits of sludge whatsoever in the drums, tubes or steam washers.

The hot process is likewise well adapted to the removal of other objectionable constituents, such as silica. By the addition of magnesium sulphate and its subsequent precipitation as magnesium hydrate, silica is adsorbed and removed, and, combined with recirculation of sludge, this provides a most economical means for reduction of silica. Since reduction of silica and reduction of hardness can be combined in one process, together with deaeration and the holding of a relatively high pH value, this process is of unusual interest. It is particularly well adapted to waters low in hardness, high in silica and coming from a turbid supply, such as surface waters, and offers the further advantage of coagulation and sedimentation without the need of additional equipment. There is considerable saving in equipment costs, operation and maintenance as compared with other methods of softening, such as a combination of the cold process and zeolite.

The only limitation to the hot process with tri-sodium phosphate as the reagent is that the alkalinity is not reduced below that originally present in the raw water. This is the same limitation that is inherent in the sodium cycle zeolite softener. However, by using phosphoric acid the alkalinity can be controlled very successfully,

while at the same time the cost for chemical is cut considerably, since phosphoric acid is cheaper than sodium phosphates on the basis of equivalent available phosphate.



Fig. 1—Sample of boiler-water concentrate after 1220 hr of steaming shown in bottle at left. That at the right contains distilled water

The following table shows the cost of phosphoric acid compared with other commonly used softening reagents. It is noteworthy that phosphoric acid can be purchased at approximately one-half the cost of other phosphates, on the basis of equivalent chemical value.

Name	Chemical Formula	% P ₂ O ₅	Price per Lb., Cents	Comparative Costs
Phosphoric acid, 75%	H ₃ PO ₄	54.5	4.0	1.00
Mono-sodium phosphate	NaH ₂ PO ₄ ·H ₂ O	51.4	9.5	2.50
Di-sodium phosphate	Na ₂ HPO ₄ ·12H ₂ O	19.8	2.6	1.78
Tri-sodium phosphate (anhydrous)	Na ₃ HPO ₄	42.7	6.25	2.12
Tri-sodium phosphate	Na ₃ PO ₄ ·12H ₂ O	18.7	2.70	1.97

Application to Soft Waters

The phosphoric acid process as applied to very soft waters having a normal alkalinity not exceeding approxi-

¹ Under the title, "Primary Treatment of Feedwater by Phosphate," in *Power Plant Engineering*, April 1936.

mately 50 ppm is carried out by introducing the acid directly ahead of the water-softening equipment. The phosphoric acid reacts with the carbonates of calcium and magnesium, liberating carbon dioxide into solution, from which it is easily disengaged in the heating and deaerating apparatus located atop the sedimentation tank. With the release of the free carbon dioxide in the deaerator, there is a corresponding reduction in the natural

and at all times the hardness, by the soap test, has been down to zero and approximately $\frac{1}{2}$ ppm by gravimetric analysis.

Results taken from a typical daily test record are as follows:

	Parts per Million			
	Alkalinities		Hardness	pH
	Ph ₂	Mo		
Raw water	0	39.0	38.5	7.2
Treated water	7	16.0	0	9.6
Boiler	154	184.0	0	11.3

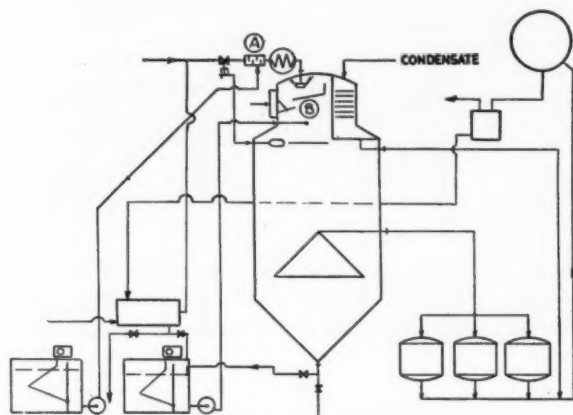


Fig. 2—Deaerating hot-process water softener utilizing treatment of phosphoric acid and caustic soda combined with magnesium sulphate for softening and silica removal; also employing recirculation of boiler water to maintain high pH values in sedimentation tank and sludge recirculation to bring about economical use of magnesium for silica removal

alkalinity of the raw water. Following deaeration, caustic soda is added for increasing the pH value and to precipitate the calcium as tri-calcium phosphate and the magnesium as magnesium hydrate. Sufficient caustic soda is added to maintain the pH value at approximately 9.7.

With ordinary soft waters phosphoric acid of itself is sufficient to control alkalinity, while if the requirement for reduction of alkalinity greatly exceeds that for precipitation of calcium, it is only necessary to add sulphuric acid along with the phosphoric acid to effect the desired control of alkalinity with the minimum consumption of phosphoric acid. Only rarely is sulphuric acid required; it is to be avoided, if possible, as it forms sodium sulphate by combining with the caustic soda added for increasing the pH value, and thereby increases the total solids.

The process described was first tried in 1941 in connection with a 700,000-lb per hr hot-process water softener operating at 30 lb gage and 274 F. The first system using phosphoric acid is diagrammatically illustrated by Fig. 2. In this case magnesium salts are added in order to obtain ionic precipitation of magnesium and thereby reduce silica. The magnesium sulphate is mixed with the phosphoric acid and the mixture fed proportionately to the raw water by a single chemical feeder. Caustic soda is added after the deaerator by a separate chemical feeding equipment.

By careful control of sludge recirculation and by the addition of magnesium sulphate, it has been possible to obtain impressive reductions in silica. For example, silica has been reduced from 12 to 2 ppm by the addition of as little as 60 ppm of magnesium sulphate (Epsom salts, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$). Test results from this plant indicate considerable flexibility in the control of the alkalinity

It will be seen that phosphoric acid makes it possible to reduce alkalinity from 39 to 16, a condition not possible with such reagents as tri-sodium phosphate. Likewise, it permits a reasonable boiler alkalinity, below 200 ppm. Tests also indicate that the excess tri-sodium phosphate in the treated water amounts to 1 to 2 ppm and the phosphate concentration in the boiler water to 30 to 35 ppm. A boiler operating at 400 lb pressure with practically 100 per cent makeup shows no sign of deposits or of sludge accumulation in steam washers, in boiler tubes or in any of the nooks and crannies where sludge usually accumulates. The boiler concentrate is practically crystal-clear at all times, which verifies the degree of softening obtained.

Another application of the process is in a plant recently placed in operation for conditioning contaminated condensate containing approximately 10 ppm of calcium salts, resulting from leakage in industrial evaporators. This condensate is returned at approximately 150 to 165 F., and was previously introduced directly into 1400-lb pressure boilers, with internal treatment by phosphate, which resulted in such accumulation of sludge that the boilers had to be taken out of service periodically for

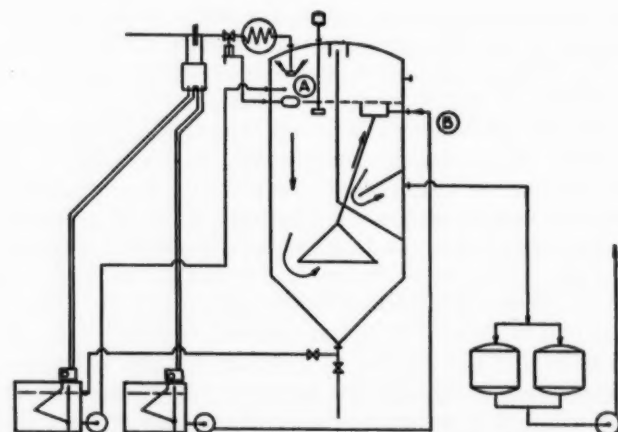


Fig. 3—Two-stage hot-process water softener utilizing treatment with lime and magnesium oxide for silica removal in Compartment A, followed by phosphoric acid as a second-stage treatment in Chamber B

inspection and cleaning. A hot-process water softener of the deaerating type, using phosphoric acid and caustic soda, was installed and its initial operation resulted in entire absence of sludge in samples of boiler concentrate. Inspection of the boiler after three months of operation showed that there is no accumulation of sludge or of deposits that interfere with the operation of the boiler. During this time the boiler delivered 576,188,000 lb of steam and it was again placed in service without internal turbing or cleaning. Previous to the installation of

this equipment, an internal phosphate treatment was used and it was necessary to take the boiler off the line every few months for internal cleaning. Now the boiler need be taken off the line only for other reasons.

A second electric generating unit will be placed in operation shortly, and the same treatment will be employed for the same feedwater for another boiler, operating at 1400 lb per sq in.

The high temperature of the condensate returns in this case, namely, 150 to 165 F., leaves the phosphoric acid method as the only means available for eliminating hardness; as other methods, such as exchange processes (zeolite softeners), are not generally considered satisfactory at these high temperatures.

Use of Phosphoric Acid in Two-Stage Softeners

The substitution of phosphoric acid in two-stage water softeners for part of the sodium salts results in lower cost of treatment. Two-stage water softeners may take one of several forms as, for example, the incorporation of two stages in a single sedimentation tank (see Fig. 3), separate sedimentation tanks in which lime-and-soda treatment is given in the first stage, followed by phosphoric acid treatment in the second stage, the sedimentation tank being of the conventional design, but having a retention time of only 45 min instead of one hour. A third form of two-stage water softener, developed by the company with which the writer is associated, consists of a deaerating stage in which phosphoric acid is used as the reagent, receiving water from an existing cold-process lime-soda softener. In a number of such installations using phosphoric acid, relatively high alkalinity is permitted in the first, or lime-soda, stage, thereby reducing the hardness to low limits and economizing on phosphate without increasing the alkalinity in the feedwater.

The use of phosphoric acid as a treating agent has increased the range of application of the hot-process softener and it may be of interest to compare the hot-process water softener of today with its predecessor of ten or fifteen years ago. When lime and soda ash were the sole treating agents, the hot process could reduce hardness to $1\frac{1}{2}$ grains per gallon. The hot-process softener of the present, on the other hand, is the most versatile method of water conditioning. It can be adapted, merely by changing the reagents, to various water supplies and shows most advantageous results with turbid waters, for which clarification, chemical conditioning and silica removal may be accomplished in a single apparatus with minimum investment, cost and operating expense. Highly alkaline waters, containing large amounts of silica, are treated with lime, gypsum or dolomitic lime while soft waters, high in silica, may be treated with phosphoric acid and magnesium sulphate. Waters of high hardness and high in magnesium require only lime and soda-ash treatment, followed by supplementary phosphate.

The integral deaerator incorporated in or forming a part of the softener sedimentation tank plays an important part in this process, as it provides for liberating the carbon dioxide before the chemical treatment has been completed. The more extensive use of the hot-process water softener with a variety of reagents indicates its adaptability, while phosphoric acid extends its use to a field not considered suitable for the hot-process water softener ten years ago.

Standard Designs Urged by Government

The War Production Board has appealed to all contractors in the fields of power plant construction, as well as oil refineries and synthetic rubber, to use, in so far as possible, only equipment of standard design.

In this connection, Howard Coonley, Chief of the Simplifications Branch of the Conservation Division, in a letter to designers and constructors, states that most of the materials used in such installations are on the critical list and that the inclusion of special designs will substantially retard production in bottleneck industries. He warned further that the war effort may compel the government to prohibit the production of "specials."

Apropos to the present situation is the following, reproduced from an editorial that appeared in COMBUSTION of September 1931.

Admittedly progress comes out of original thinking, from the desire to do things differently, presumably in order to do them better—but why must the engineer who sees for the first time a drawing of a new design or a layout for a new plant, evidence an irresistible urge to grab his pencil and start changing?

In the field of steam plant equipment, this urge, familiar to every designer and equipment salesman, has wasted countless hours of time, delayed construction projects and has cost enormous sums of money, frequently without the gain of a single worthwhile advantage and not infrequently with the actual impairment of the value of the original scheme.

A boiler and furnace layout offers wide latitude to the engineer with the "change it" complex. Despite the fact that it comes to him from the hands of specialists, men whose experience represents years of intimate contact with similar problems, he regards the suggested design as a mere background upon which his ever ready pencil can portray his many personal ideas of improvement.

He would not think of insisting that a manufacturer of turbines or pumps change the design of his product since such equipment is highly standardized and is sold as a unit, but simply because the design of steam generating units is more flexible, he is ever alert to inject into the scheme presented as many of his own ideas as possible.

Fortunately, this attitude is not characteristic of all engineers. In fact, the highly competent and experienced engineer is pretty apt to confine his analysis to the general features of the scheme submitted, checking them as to their general conformity to his requirements and either approving or disapproving accordingly. His attitude and procedure are based on the correct assumption that a reputable manufacturer knows how to design his own equipment and apply it to meet specific conditions. Furthermore, he is unwilling to assume the responsibility of insisting on extensive changes which will probably represent a compromise between his own ideas and those of the manufacturer and which may jeopardize, rather than improve, the performance of the installation.

Canada May Ration Power

Reports from Canada indicate that the present extremely heavy power demands for war production, particularly in Ontario and Quebec, are taxing existing facilities and may make necessary the application of rationing later this fall when the seasonal peak begins. In that case, restrictions would be applied to many non-essential uses of electricity and certain industries that are not directly related to the production of war materials will likely be rationed. Definite plans for such restrictions and for the further diversion of power are understood to have been made. While these eastern provinces are supplied largely by hydroelectric power, all available reserve steam capacity is also now being brought into use.

WPB Curtails Utility Projects

As a result of a survey of actual war needs and the materials available, many of the projects advanced in the program that was announced by the Federal Power Commission about a year ago have now been suspended by order of the War Production Board. Those remaining will account for 5½ million kilowatts in new capacity to be added from now till early in 1944. Construction on certain long-range federal projects, mostly hydro, will proceed at a reduced rate and in such a way as not to compete for critical materials.

THE War Production Board announced on August 22 the issuance of a series of orders to effect a readjustment of the power expansion program. These involve extensive revision of existing priority ratings on public and private power projects throughout the country. All utility projects which are regarded as urgently necessary in the war program have been assigned higher priorities in order to assure their completion on schedule. In the case of the remaining projects, action has been taken so that they will not compete with immediate military requirements for critical materials and equipment, particularly equipment needed for the Navy and merchant ship programs, and copper and steel. This has meant the halting of some projects and continuance of another group only to the extent possible on low ratings.

The decisions were the result of a comprehensive review of the electric utility construction program in the light of the power supply and requirements situation. This review, recently completed, has been under way since the late spring, in line with a general policy of proceeding only with such heavy construction as is indispensable to the immediate war program.

In the program of projects to be assured completion, 5,500,000 kw of new capacity are provided for the remainder of 1942, 1943 and, to a limited extent, early in 1944. Of this amount, 3,400,000 kw is private and 2,100,000 kw public. Work on projects totaling 2,200,000 kw, scheduled for operation in 1943 and 1944, is being stopped. Of this amount, 355,000 kw represents capacity on which priorities are being suspended subject to reinstatement in the future should changing power requirements dictate such action.

Low-Rated Federal Projects

In addition, projects totaling 1,890,000 kw, scheduled for installation in 1943, 1944 and 1945 and authorized by the Congress as part of the program for federal generating projects, are being reduced to low ratings, or are being held to their present low rated or non-rated status. Work on the low rated projects is permitted to continue but only to the extent that it does not compete for critical materials and equipment needed for direct war

uses. For the most part, these federal projects are hydroelectric developments on which, unlike steam plants, some construction operations can be carried on without requiring critical materials. The work done under the low ratings will facilitate expediting these federal projects later, if necessary.

In conjunction with existing power installations, the projects that have been given the higher priorities are designed to assure supply for war and indirect war production as now planned, with a small margin of capacity to provide for possible additional war production not included in the munitions program as now projected. It has been necessary to hold this margin to the minimum and the risks involved in such action represent the price that must be paid for releasing materials needed immediately for direct military uses.

Definite Planning Now Possible

Because such a large part of the war program is now definitely planned for, it is feasible to plan for the electric capacity with more precision than was heretofore possible. At the same time, it was emphasized that the reduction in the utility expansion program has substantially enhanced the probability of widespread curtailment in the use of electricity for civilian purposes, especially during 1943 and thereafter. It was explained that the necessity for diverting critical materials and equipment to the direct war program makes it impossible to carry out a utility expansion program that would preserve the standards of reliability of service observed in peacetime, that civilian inconvenience and sacrifice must be expected, particularly during periods of drought or other adverse weather conditions, in the event of serious accidents affecting utility systems, or in case of unexpected large increases in power requirements for war production.

The federal projects and the projects on which priorities are being suspended are designed to provide a margin of potential source of power supply that can be brought into operation speedily to relieve later power deficiencies. A close check is being maintained continuously by the War Production Board on power supply and requirements in order that action may be taken as promptly as possible to reinstate or speed up these projects or initiate new ones as needs arise.

The accompanying list shows the projects to be halted or suspended and the government projects permitted to proceed only under low priorities.

PROJECTS HALTED OR SUSPENDED, IN WHOLE OR IN PART

COMPANY OR AUTHORITY	PLANT OR LOCATION
Albuquerque Gas & Electric Co.	Albuquerque, N. M.
Austin, City of	Austin, Minn.
Bellefontaine, City of	Bellefontaine, O.
Benton, City of	Benton, Ark.
Berea, City of	Berea, O.
Boston Edison Co.	Mystic No. 2
Central Illinois Elec. & Gas Co.	Rockford
Central Illinois Pub. Serv. Co.	Meredosia
Central Maine Power Co.	Wiscasset
Clarksdale, City of	Clarksdale, Miss.
Colorado Springs, City of	Colorado Springs, Colo.
Columbus & Southern Ohio Elec. Co.	Picway
Commonwealth Edison Co.	Walnut Street
Connecticut Lt. and Pr. Co.	Fisk No. 18
Consolidated Edison Co.	Devon, Conn.
Consumers Power Co.	Hell Gate
	Weadock

Dallas Pr. & Lt. Co.
Dayton Pr. & Lt. Co.
Des Moines Elec. Lt. Co.
Ephrata, Borough of
Fairmont, City of
Farmers Elec. Gen. Corp.
Flora, City of
Florida Power Corp.
Ft. Dodge Gas & Elec. Co.
Glendale, City of
Gulf Power Co.
Gunnison, Town of
Hinsdale, Village of
Illinois-Iowa Power Co.
Illinois Northern Utilities Co.
Iowa Electric Lt. & Pr. Co.
Iowa Electric Lt. & Pr. Co.
Iowa Public Service Co.
Jersey Central Pr. & Lt. Co.
Jones Onslow Elec. Membership
Kansas City
Kansas City Pr. & Lt. Co.
Kentucky Utilities
Los Angeles, City of
Lynn Gas and Elec. Co.
Marshfield, City of
Metropolitan Edison Co.
Mississippi Power Co.
Missouri Pr. and Lt. Co.
Monroe, City of
Montaup Elec. Co.
Murray City
Narragansett Elec. Co.
New Jersey Pr. & Lt. Co.
Northwestern Public Serv. Co.
Ohio Edison Co.
Ohio Power Co.
Ohio River Power Co.
Pacific Gas & Elec. Co.
Pacific Gas & Elec. Co.
Pennsylvania Pr. & Lt. Co.
Philadelphia Elec. Co.
Potomac Electric Power Co.
Princeton, City of
Produce Terminal Corp.
Public Service Co. of Ind.
Public Serv. of New Hampshire
Public Serv. of Oklahoma
Reading, City of
Richmond, City of
San Antonio Pub. Serv. Co.
San Diego Gas & Elec. Co.
Southern Indiana Gas & Elec. Co.
Southern Indiana Power Co.
Springfield Gas & Elec. Co.
Southwestern Gas & Elec. Co.
St. Joseph Ry., Lt. Ry. & Pr. Co.
Tacoma, City of
Tampa Electric Co.
Tarentum, Borough of
Traverse City, City of
Union Elec. Co.
United Illuminating Co.
Virginia Elec. and Pr. Co.
Windom, City of
Wisconsin Hydroelectric Co.
Wisconsin Pr. & Lt. Co.

Mountain Creek
Millers Ford
Des Moines
Ephrata, Pa.
Fairmont, Minn.
Gilmer, Tex.
Flora, Ill.
St. Petersburg, Fla.
Ft. Dodge, Ia.
Glendale, Calif.
Pensacola, Fla.
Gunnison, Colo.
Hinsdale, Ill.
Peoria, Ill.
Dixon, Ill.
Marshalltown, Ia.
Boone, Ia.
Sheldon, Ia.
Raritan River, N. J.
Jacksonville, N. C.
Quindaro, Kans.
Grand Avenue, Kansas City, Mo.
Tyrone, Ky.
Harbor, Los Angeles
Broad St., Lynn, Mass.
Marshfield, Wis.
Middletown, Pa.
Hattiesburg
Mexico, Mo.
Monroe, La.
Somerset, Mass.
Murray City, Utah
Westerly, R. I.
Gilbert, N. J.
Aberdeen, S. D.
Toronto, O.
Tidd
Dilles Bottom
Midway
(Indefinite)
Williamsport, Pa.
Southwark, Phila.
Buzzard Point, No. 6
Princeton, Ill.
Chicago, Ill.
Edwardsport, Ind.
Manchester, N. H.
Tulsa, Okla.
Reading, O.
Richmond, Ind.
Station B
Silver Gate
Ohio River Station
Rushville, Ind.
Springfield, Mo.
Caddo Lake
Lake Road
Alder Nos. 1, 2
W. Jackson St.
Tarentum, Pa.
Traverse City, Mich.
Venice No. 2, Unit No. 4
Steel Point, Bridgeport, Conn.
Norfolk, Va.
Windom, Minn.
Clear Lake, Wis.
Beloit, Wis.

Facts and Figures

The total capacity of electric generating plants, supplying power for general use in the United States as of July 31, 1942, was 45,620,864 kw.

The first large commercial 1200-lb pressure boiler installation in the United States was made in 1925: one for 1800 lb went into service in 1931; and one for 2400 lb in 1941.

Slagging troubles when burning fuel oil are not infrequent. They are attributed to residues in the oil resulting from refining processes in which soda and other salts are employed.

A 50,000-kw condensing turbine operating at around 900 F total steam temperature may have an overall change in length as much as $\frac{3}{4}$ in. in passing through its normal heating and cooling cycle.

The largest single traveling grate stoker, which has lately been installed in a chemical manufacturing plant, is 28 by 24 ft with a grate surface of 672 sq ft. It burns No. 4 buckwheat.

There are, at present, in operation in this country, nine steam generating units with individual outputs of over a million pounds of steam per hour, and another is now being installed. Of these, four are high-pressure, high-temperature units.

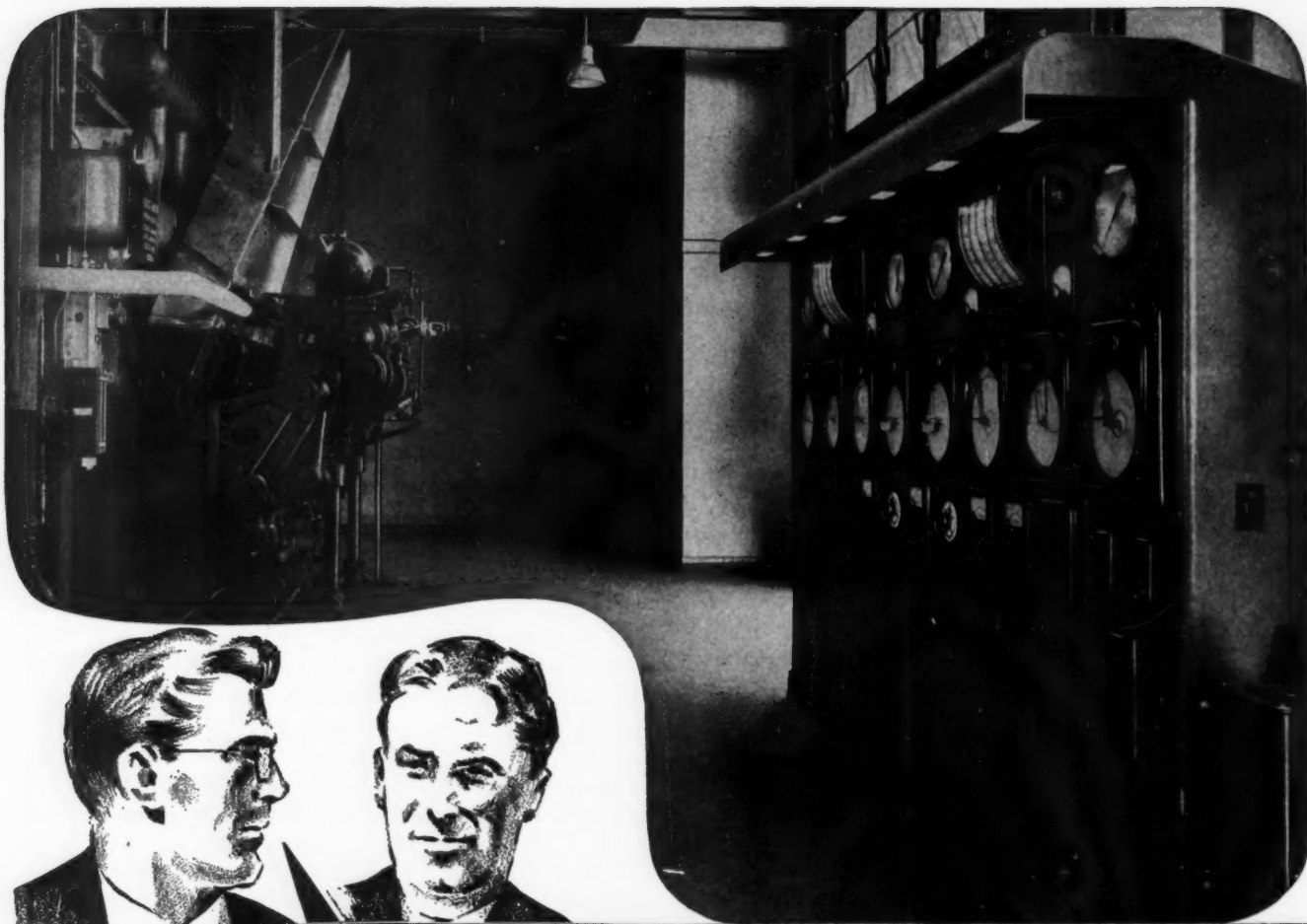
A film of scale only $\frac{1}{100}$ in. thick on the inside of a tube may, under some conditions, raise the hot-face temperature of the tube several hundred degrees. Much depends, of course, on the composition of the scale.

The fate of the airplane carrier *Lexington* in the Coral Sea brings to mind the fact that this vessel, which had an electric generating capacity of 160,000 kw, late in 1929 supplied emergency electric service for about a month to the City of Tacoma during a severe drought which greatly curtailed hydroelectric power in the Northwest.

Steam pressure and the size of unit influence the length of time normally employed in bringing a boiler up to operating pressure. With large high-pressure boilers it is customary to bring the steam pressure up to about 250 or 300 lb in the first two hours and then up to full pressure in the next two hours. With small or medium-sized boilers operating under 300 lb pressure, one to one and a half hours are usually considered sufficient. However, care should be taken not to cool down a boiler too rapidly when taking it out of service as the tubes cool more rapidly than the drum and leaks may develop.

GOVERNMENT PROJECTS PROCEEDING ON LOW PRIORITIES OR UNRATED

AGENCY	PLANT	LOCATION
Tennessee Valley	Wilson Nos. 15, 16	Alabama
	Watts Bar No. 4 (Steam)	Tennessee
	Pickwick No. 5	Tennessee
	Ft. Loudon Nos. 3, 4	Tennessee
	Guntersville No. 4	Alabama
	Chickamauga No. 4	Tennessee
	Wautaga Nos. 1, 2	Tennessee
	Wheeler Nos. 5, 6	Alabama
	South Holston Nos. 1, 2	Tennessee
	Wilson (Steam)	Alabama
	Fontana No. 3	North Carolina
	Kentucky Nos. 3, 4, 5	Kentucky
U. S. Engineers	Bluestone	West Virginia
	Markham Ferry	Oklahoma
	Wolf Creek	Kentucky
	Center Hill	Tennessee
	Allatoona	Georgia
	Norfolk No. 2	Arkansas
	Fort Peck No. 2	Montana
U. S. Bureau of Reclamation	Fort Gibson	Oklahoma
	Denison No. 2	Texas-Oklahoma
	Colorado-Big Thompson	Colorado
	Anderson Ranch	Idaho
	Keswick No. 3	California
Federal Works Agency	Davis Nos. 1, 2, 3, 4, 5	Arizona-Nevada
	Pensacola	Oklahoma
Bonneville Administration	High Point	North Carolina
	Grand Coulee Nos. 7, 8, 9	Washington



**"WE SELECTED HAYS CONTROL BECAUSE IT IS
EASIER FOR OUR OPERATORS TO UNDERSTAND"**

...So said **THE CHIEF ENGINEER** of the above boiler room located in a mid-west municipal light plant. He went on to explain to two engineers* who were investigating several combustion control systems—

"Our men lived with Hays Automatic Combustion Control in our old plant for several years and they liked its simplicity, and its positive operation. Because it was easier to understand than the other systems on the market they took a keener interest in it and produced better results."

"Before selecting boiler control for our new high pressure plant I made trips to several near by cities inspecting the most recent installations of all types of control systems. These trips served to confirm my original opinion of Hays, so we selected Hays for our new plant also."

*The result of this interview was the sale of complete Hays Automatic Combustion Control for 7 boilers in a large automotive product plant.

HAYS *automatic* **COMBUSTION CONTROL**

is being preferred more and more over other control systems for very definite reasons. In the first place it is completely electric, which simplifies design, installation and operation.

It is the only system that has all instruments and controllers centralized on a single panel and not scattered all over the boiler room or hung on the side of the boiler. Adjustments are direct and not dependent on air pressures, oil pressures, and the complicated valve mechanisms made necessary by most other designs.

You will want to learn more about this thoroughly modern system that is maintaining boiler room efficiency and lowering operating costs in hundreds of plants. Send for 40-page catalog 41-304 today.

The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

The Law of Patent Infringement

By LEO T. PARKER

Attorney, Cincinnati, Ohio

Although industry is now engaged mostly in war production, researchers and designers in many lines are giving serious thought to meeting post-war conditions and to designs that will utilize materials born of war necessity. It is a matter of record that most war and immediate post-war periods have been especially productive of inventions. It is believed, therefore, that the following notes on patent infringement may be helpful to many engineers and companies at this time.

IN A suit for infringement of a patent the three fundamental questions are:

1. Has the patentee invented something?
2. Is the invention described in the specification?
3. Is it covered by the claim?

If these questions can be answered in the affirmative, an infringer who has appropriated all the advantages of the invention, although by ingenious changes of form, usually cannot escape accounting to the owner of the patent (1).¹

Infringement suits must be brought in the district in which the infringer has his residence or in the district in which the infringement acts are committed provided the infringer has a regular and established business there.

The amount of damages recoverable from an infringer of a patent varies with the conditions of infringement and circumstances of the case, but is generally based on the damages caused to the patentee and the amount of profits realized by the infringer (2).

Whenever a verdict is rendered sustaining a willful infringement, the court may, if it so desires, enter judgment against the infringer for *three times* the amount of the verdict, but this is rarely done (3).

If on the proofs it appears that the owner of the patent has suffered damages, or the infringer has realized profits, but such damages and profits are uncalculated with reasonable certainty, the court may receive opinions from experts and sustain a reasonable sum as profits or general damages (4).

Who May Infringe

Innocence is no excuse and does not avoid infringement. If the party who manufactures an article is an infringer, and sells to a wholesale firm who sells to a retail firm who, in turn, sells to an individual purchaser, they are all infringers and they are liable as such, ex-

cept where the article is made under a *process patent*, and the article itself is not patented; then the innocent purchaser is not liable. Infringement is considered in legal terms "a tort," and a minor is liable (5).

Joint Ownership

A joint owner of a patent cannot be an infringer thereof and either owner has a full and separate right to make, sell and license the use of the invention, without interference from the other unless a contract limiting their rights exists between them (6). The exercise of the entire monopoly conferred by a patent can be effected only by joint action of all owners (7), and an owner of an undivided part of all rights secured to a patent may without consent of any other owner sell or grant a valid license to use the monopoly secured by the patent (8). A co-partner is not an infringer because of the acts of his partner and is not liable unless the firm receives benefits therefrom or unless the firm itself is the infringer.

Contrary to general opinion, a person may not make a patented article as a whole or any part thereof *even for his own use*, unless he acquired the original patented article or machine legally and then he is permitted to make only such parts of the device as are actually needed for repairs; but the making of an old machine practically new is infringement (9).

Different persons who make different parts of a patented device and then assemble the parts to form the patented article are *all* liable as co-infringers (10, 11, 12, 13).

Infringement cannot be avoided by adding to a patented article or by changing the form of the device or by changing the material of which it is made where neither affects the functions performed by the machine (14). Substituting an element which works no change in the unitary result does not avoid infringement (15); and mere changes such as splitting up or multiplication of parts does not avoid infringement (16, 17, 18). Making in one piece that which the invention made in two or more pieces is a crude attempt and does not avoid in-

¹ Numbers in parentheses signify references in Bibliography.

fringement (19, 20, 21), unless a new or beneficial result is obtained and then it is invention and infringement is avoided (22).

A very safe rule to follow is, mere changes of the form of a device or of some of the mechanical elements secured by a patent will not avoid infringement, where the principle of the patented invention is adapted, unless the form of the machine or of the elements changed are the distinguishing characteristics of the invention (23).

A machine that infringes part of the time is a full infringement (24).

Improving a patented device does not avoid infringement (25), and furthermore, an improver of a patented invention cannot appropriate the original invention even though the improvement is patented (26), for the reason that an improvement is merely an addition to the original invention.

The absence of a single element essential to the invention avoids infringement (27, 28, 29), but substitution cannot be made for the part omitted by a "mechanical equivalent" which is a part equivalent in action to another part. When a part is different in construction and cannot be substituted for another it is not a mechanical equivalent and there is no infringement (30, 31). In forming an opinion as to whether or not a part is a mechanical equivalent of another, the character of the patent as well as the action of the parts being compared must be considered and also a part to be a mechanical equivalent must have been well known as a substitute at the time of filing the application (32).

Mechanical Equivalent Defined

The term "mechanical equivalent," when applied to the interpretation of a pioneer patent, has a broad and generous signification. When applied to a slight and almost immaterial improvement, it has a very narrow and limited meaning. When applied to that great majority of inventions which fall between these two extremes, its significance is proportioned to the character of the advance or invention under consideration, and it is so interpreted by the courts as to protect the inventor against piracy and the public against monopoly (33).

A pioneer patent is generally conceded to be one which relates to a distinctively different invention or device than has been previously used or patented. It may relate to a totally new art or to a small portion of a known art or device which invention in itself is broadly new or produces broadly new results. It need not be for an article that is entirely new but may be for an article or machine of known type and if it *greatly reduces the cost of manufacturing the article* it is a pioneer patent (34). It has been held that under certain circumstances an improvement claim is entitled to as liberal construction as the basic machine, but generally where the field is limited, a narrow improvement may not be considered a mechanical equivalent (35, 36, 37).

Of course, a mechanical equivalent simply is a thing, device or element of such character that any one experienced in the particular art, to which the improvement is related, may immediately and without difficulty make the substitution. If one experienced in the art cannot by ordinary observation make the substitution, then this is invention and the part, device or element is not a mechanical equivalent, but the inventor is entitled to a patent on his invention.

This is new law, as established by late and leading higher court cases during May 1942. The law always has been to this practical effect, but recently the courts are in accord with the proposition that inventors should be able to obtain patents and secure protection if they invent something not generally known and not generally so similar to other known devices that any one could make a substitution.

The Law of Anticipation

Anticipation in the Law of Patents means that an issued patent is invalid or that an application for a patent will not be granted because of various reasons, the most common of which are that the same device has been patented, described in a printed publication or known and successfully used previous to the invention thereof by the person or persons endeavoring to sustain the anticipated patent or patent application.

To anticipate an invention, it must be proved beyond a reasonable doubt in the mind of the Court (38) and if anticipated by a machine the new and the old device must operate on the same principle (39). Mere accidental use, when the beneficial results are not recognized, does not anticipate a patent (40) nor where it was used only for experimental purposes (41).

Where the old device might easily have been modified to perform the functions of the new device and the inventor of the old device did not have in mind the new function, the new patent is valid and is not anticipated (42). Even if the new function appears in a machine made under a patent, if it was accidental, unrecognized by the original inventor and no disclosure thereof was made to the public the new patent is valid (43, 44).

A drawing of an old patent or photograph on such small scale as not to present clearly the device is not anticipation (45), and a mere drawing without written descriptive matter even if the drawing is plain is not anticipation.

Result or Function

A result or function of a machine or device is not patentable (46, 47), but the means by which a result or function is accomplished is patentable (48). However, there is no objection to a patentee stating or describing a result or function of a machine in the claims of a patent provided the mechanism is fully set forth, but the patent issues for the means and not for the result (49, 50).

A claim specifying "means for quickly adjusting" is functional and invalid unless the mechanism is clearly in the specification or drawing (51). It is not unusual to observe patent claims which after explaining the construction of the mechanism continue with a "whereby clause" stating the function. This latter clause is superfluous and adds nothing to the claims.

The real test whether a functional claim is invalid is: "Does it extend beyond the broad equivalency of which the invention permits?" (52).

Process Patents

A process patent relates to the mode or method employed in producing a thing or result. A process is not a machine, a thing or result (53). In other words a patentable process must relate to the steps necessary in making something or producing a result. All of the steps may be old individually, but unless it further appears

that the steps have been employed in the same relation it is valid (54, 55).

To support a process patent there must be a tangible product or change in character or quality brought about and not merely a mechanical or electrical principle or result (56); but when the new results come from certain acts or a series of steps irrespective of the mechanism the method is patentable (57).

To constitute an infringement of a process patent it is not necessary that the two processes should be identical in all particulars, but it is sufficient if in general aspects they are the same (58).

Apparatus Distinguished From Process

Usually the apparatus or machinery employed in carrying out a process for making an article or producing a result must be patented separately from the process itself (59), but it is not necessary that the machinery or apparatus be new and patentable to secure a valid process patent (60, 61).

If the process and apparatus are mutually dependent they may be joined in one application (62), but the Patent Office rules upon each case individually and sometimes may even permit a process, a machine for carrying out the process and the article made by the machine and process to be included in one application (63). Nevertheless it is best and safe for an inventor to apply for separate patents (64). However, the possibility of double patenting should be watched.

A single claim cannot cover both a process and a machine (65, 66). The specification must enumerate the steps or ingredients in a process patent and if any claim describes fewer steps or ingredients than the specification makes essential that claim is void (67).

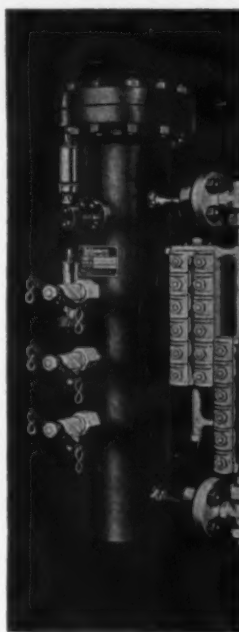
A machine patent usually may not reissue to cover a process or vice versa (68); nor can a process patent reissue to cover a product patent (69). But it may be secured in a separate application if the last application is filed not more than two years after the first patent issues (70).

BIBLIOGRAPHY

F. refers to "Federal Reporter," O. G. to the Patent "Office Gazette" and U. S. to Reports of the U. S. Supreme Court. Case numbers precede these references, and page numbers follow them.

- | | |
|---------------------|----------------------|
| (1) 111 F. 172. | (36) 208 F. 1005. |
| (2) 238 F. 369. | (37) 219 F. 753. |
| (3) 283 F. 873. | (38) 165 F. 927. |
| (4) 275 F. 315. | (39) 173 F. 280. |
| (5) 258 F. 650. | (40) 136 F. 859. |
| (6) 262 F. 131. | (41) 177 F. 261. |
| (7) 108 F. 71. | (42) 148 F. 239. |
| (8) 129 F. 594. | (43) 124 F. 486. |
| (9) 161 F. 748. | (44) 286 F. 79. |
| (10) 112 F. 146. | (45) 275 F. 448. |
| (11) 186 F. 637. | (46) 170 U. S. 537. |
| (12) 224 F. 452. | (47) 90 U. S. 181. |
| (13) 118 F. 52. | (48) 126 U. S. 531. |
| (14) 228 F. 127. | (49) 170 O. G. 1089. |
| (15) 227 F. 120. | (50) 189 F. 741. |
| (16) 156 F. 49. | (51) 283 F. 58. |
| (17) 155 F. 976. | (52) 228 F. 691. |
| (18) 222 F. 906. | (53) 263 F. 106. |
| (19) 190 F. 189. | (54) 261 F. 89. |
| (20) 230 F. 120. | (55) 189 F. 359. |
| (21) 263 F. 89. | (56) 135 F. 785. |
| (22) 151 F. 223. | (57) 246 F. 135. |
| (23) 106 F. 693. | (58) 190 F. 573. |
| (24) 211 F. 654. | (59) 91 O. G. 459. |
| (25) 258 F. 122. | (60) 150 F. 355. |
| (26) 261 F. 192. | (61) 191 F. 588. |
| (27) 171 F. 656. | (62) 192 U. S. 543. |
| (28) 162 F. 150. | (63) 13 O. G. 288. |
| (29) 210 F. 26. | (64) 189 F. 359. |
| (30) 189 U. S. 8. | (65) 34 F. 899. |
| (31) 198 U. S. 399. | (66) 126 U. S. 1. |
| (32) 169 F. 793. | (67) 146 F. 517. |
| (33) 106 F. 693. | (68) 131 F. 740. |
| (34) 293 O. G. 215. | (69) 189 F. 611. |
| (35) 133 F. 920. | (70) 190 F. 573. |

PREVENT POWER BREAKS



...Patrol your vital
boiler water levels with

Reliance ALARM Safety Water Columns!

They stand guard at your
boiler drums—respond
instantly with warning
whistle when water levels
go too low or too high for
safety. Write for catalog.
Give working pressure.

The Reliance Gauge Column Co.
5902 Carnegie Avenue • Cleveland, Ohio

Reliance
Boiler Safety Devices since 1884

For Longer-Life Furnace Linings



lay them up with
ADAMANT
FIRE BRICK CEMENT
that makes the Joints
as strong as the
bricks they bond

Impartial laboratory tests
prove ADAMANT has a
bonding strength of 800
lbs. per sq. inch at room
temperature — 1270 lbs.
per sq. inch at 2600°F.
This means fewer shut-
downs for relining.

ADAMANT comes ready-mixed and is extremely
smooth—over 66% of the dry material passing through
a 200 mesh standard Tyler sieve.
Packed in 100, 250 and 500 lb. air-
tight drums. Write for details—now.

BOTFIELD
REFRACTORIES COMPANY

776 S. Swanson St., Philadelphia, Pa.
In Canada, Canadian Botfield Refractories Co.
Ltd., 171 Eastern Avenue, Toronto



ADAMANT has a
P. C. E. of over
3000°F.



Nearly 3000 Combustion workers crowd the large bay in which the presentation took place

MARITIME Makes Combustion

IN RECOGNITION of outstanding achievements in the building of boilers for the Liberty Ships and other vessels included in the Maritime Commission's program, Combustion Engineering Company has been awarded the "M" Pennant, the Victory Fleet Flag and the Labor Merit Insignia for employees, by the Maritime Commission Board of Awards.

The presentation of these awards by Admiral Emory S. Land was the occasion of a colorful ceremony at the Company's Chattanooga Plant on the afternoon of September first. A. J. Moses, Vice-President and General Manager of the Hedges-Walsh-Weidner Division, accepted the "M" Pennant on behalf of the company and the employees of the plant; and the Labor Merit Insignia was accepted, for all the plant employees, by four of the oldest men in point of service. J. V. Santry, President of Combustion Engineering Company,

spoke on the significance of the awards and the responsibilities they entailed.

Other addresses were made by Col. Chas. Kerwood, representing the Under Secretary of War and Chief of the Air Force, by Representative Estes Kefauver and by Edward Bass, Mayor of Chattanooga. They were introduced by Dr. Alex Guerry, Vice-Chancellor of the University of the South. The program was further enlivened by the participation of Greer Garson, of "Mrs. Miniver" fame. Music was furnished by the Provost Marshal General School Band of Fort Oglethorpe and Miss Jane Moses rendered appropriate vocal solos.

Remarks by Admiral Land

"We in the United States are today showing the Axis Powers just what their pet expression 'total war' means," said Admiral Land. "We are showing them that Ameri-



"M" Pennant and Victory Flag displayed by (left to right) J. V. Santry, President; A. J. Moses, Vice-Pres. and Gen. Mgr. of Company's Chattanooga plants; and Admiral Land



Greer Garson, star of "Mrs. Miniver," makes an eloquent appeal to buy War Bonds and Stamps

COMMISSION Awards to Engineering Co.

Nearly 100 honored guests occupied the colorfully decorated platform



can total war stands for total mobilization not only of our fighting forces, but also of our entire industrial and economic system. It means a mighty drive of coordinated production, and distribution of the armaments, munitions and supplies necessary to supply our fighting forces throughout the world."

Despite broadcasts from Berlin, Rome and Tokio, to the contrary, the Admiral emphatically stated that we are not only meeting the shipbuilding program on time, but through the full cooperation of labor and management in every plant supplying materials that go into ships, we are beating the schedule and are well on the way to realizing the objective of producing 2300 ships, of 24,000,000 aggregate dead-weight tons, by the end of '43. Referring to the fact that Combustion Engineering Company had contracted to supply boilers for between 35 and 40 per cent of the entire shipbuilding program of

the Maritime Commission, he alluded to the slogan adopted by the men at the Chattanooga plant, saying: "The workers of Combustion Engineering Company have a slogan that appeals to me tremendously—'Pass the Schedule—Not the Buck.' Believe me, that's a good one. I have memorized it and I am going to spread it around. I hope you will make it a byword in your daily work; yes, even a household phrase for the inspiration of your families and friends. You have trained your minds to think in terms of what the slogan implies and have developed an objectivity which is priceless in our war effort.

"Boilers mean ships, and every ship means that tanks, guns, ammunition, food and medical supplies will go out to our boys in England, Australia, the Solomon Islands or wherever else they may be. Make this war a personal war for the benefit of your pals on the Global war front."



J. V. Santry, President of Combustion, accepts the challenge of the award



Admiral Land presents Labor Merit Insignia to oldest workers in each department. Colored worker has 48 years of service

Response

In responding to Admiral Land, Mr. Moses said, "When we think of the boilers we are building, we do not think of them merely as drums, headers and tubes, but rather as the source of power that will carry American ships through the seven seas with equipment and supplies needed to bring utter defeat to Hitler and the Axis Powers. Because this is our conception of our job, we are not going to regard our achievements in the past as a measure of what we shall do in the future. We are determined to better those achievements." He assured the Admiral that he reflected the spirit of the men in his organization when he promised that nothing would stop them from earning the right to keep the "M" Pennant flying over the plant until the battle is won.

Remarks by J. V. Santry

Mr. Santry prefaced his remarks with a tribute to Admiral Land, recalling that 42 years ago the latter, then a half-back cadet on the Annapolis football team, had by a brilliant run clinched a victory for the Navy over the Army in the last few minutes of play in a seemingly tie-score game.

After graduation at the head of his class he had been sent to Massachusetts Institute of Technology as an honor student in naval construction. Following an illustrious naval career he retired in 1937 and was later selected by the President to head the vast maritime program of the Government.

The speaker also referred to Admiral Vickery, of the Maritime Commission, recalling that eighteen months

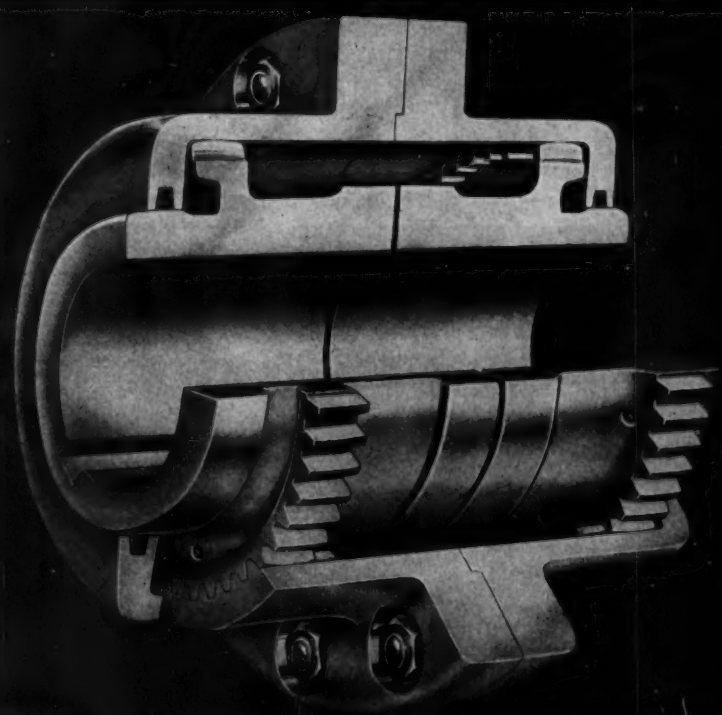
ago the latter, forced with the necessity of finding additional capacity throughout the country for the manufacture of marine boilers, had investigated the record and facilities of Combustion Engineering Company in building stationary boilers and, as a result, had placed an initial order for 50 per cent of the Liberty ship boilers then projected. On the basis of performance with this order, the contract was later increased fivefold with the result that the Company is furnishing boilers for approximately 800 ships. "Who knows," said Mr. Santry, "before this conflict is over it may mean 1500 or 2000."

In acknowledging the challenge of the award, Mr. Santry congratulated the employees on the work they had done to date and pledged their further efforts in carrying out the work mentioned by Admiral Land, with assurance that six months from now another star will be added to the pennant.

Welding Society Meeting

The Twenty-Third Annual Meeting of the American Welding Society is scheduled for the week of October 12 at Cleveland, O. Headquarters and Meetings will be at the Hotel Cleveland and concurrently the National Metal Exposition will occupy the Municipal Auditorium. Technical sessions will be devoted to training of welding operators and their qualifications, fatigue and impact, war production, weldability of steels, aircraft, ordnance and shipbuilding welding, resistance welding and non-destructive tests and inspection. In all, over fifty technical papers are scheduled for presentation, as well as several motion picture films.

**P
O
O
L
E**



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY **WOODBERRY, BALTIMORE, MD.**

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

The Marine Power Plant

By Lawrence B. Chapman

In the second edition of this excellent text, the student will find a short but direct and thorough introduction to the fundamentals of the selection and design of steam and diesel propulsion plants. The marine engineer will find it refreshing with many helpful guides to design procedure and computation and to revealing comparisons for the proper selection of equipment. Owner and operators will find it similarly useful, and in addition may utilize it to check the results and correct the operation of their vessels.

Fundamentals and thermodynamic principles are set forth in a manner easily comprehended and descriptions of marine equipment are handled with clarity. In the selection of equipment, the latest practices are brought out but sight has not been lost of installations of the recent past—of ships that will be in operation for some years to come.

There are chapters on Fuels, Marine Boilers, Combustion, Reciprocating Steam Engines, Geared Turbines, Turbo-electric Drive, Diesel Engines, Comparisons of Types of Propelling Machinery, Condensers and Their Auxiliaries, Power Plant Layouts, and Computations for the Power Plants of Merchant Ships. Those chapters on comparisons and on computations will be especially interesting and revealing to many.

Lawrence B. Chapman, Professor of Marine Transportation and Marine Engineering at the Massachusetts Institute of Technology, has brought to the reader a wealth of information and data out of his broad knowledge of this field, and has set it before him in a concise and readily usable form, shorn of non-essentials. The book comprises 402 pages, size 6 X 9, and includes 130 illustrations. Price \$4.00.

Mathematics Dictionary

By Glenn James, assisted by Robert C. James

The multitude of facts that one has once learned in assimilating courses in algebra, trigonometry, geometry and the calculus can seldom be retained in the conscious mind for more than a brief period after college, and when the occasion arises where such knowledge is useful or necessary neither the time nor the facilities are usually available to "look it up." For this reason Professor Glenn James and his associate, Robert C. James, are to be congratulated in compiling an invaluable work of reference for students, teachers and workers in other fields such as physics, statistics, finance and astronomy where mathematics are an essential feature.

The "Mathematics Dictionary" may prove to be the basis of an evolutionary standardization of mathematical terms in

that it furnishes a clear and concise definition of basic words and topic phrases, which includes a complete coverage of all terms from Arithmetic through the Calculus and also the formulas and the technical terms used in the application of these subjects. All mathematical terms used in the definitions are themselves defined, and to further clarify the meaning of the text, illustrative examples and drawings are freely used. This section of the book comprises 250 pages; a supplementary 22-page appendix includes mathematical tables, formulas and symbols.

Bound in blue fabricoid, size 6½ X 9¼. Price \$3.00 post paid.

Standard for Instruction of Welding Operators

The American Welding Society has recently approved and published a new tentative standard, entitled "Code of Minimum Requirements for Instruction of Welding Operators, Part A—Arc Welding of Steel ⅜ to ¾ In. Thick."

The sections in the main body of the Code include: equipment and facilities of

the school, qualifications and duties of the instructor, instruction in welding practice, instruction in welding theory, and final tests. There are nine appendices of suggested and recommended material, as follows: accessory equipment for welding schools, design of positioning equipment, designs of testing apparatus and their application, safety rules for student arc-welding operators, welding electrodes, arc-welding exercises, student progress chart, form for record card, selected bibliography of publications relating to arc-welding instruction.

This Code is published in the form of an illustrated 68-page booklet, size 6 X 9, with heavy paper covers. Price 50 cents.

Typical Analyses of Coals of the United States

By A. C. Fielder, W. E. Rice and H. E. Moran, Bureau of Mines Bulletin 446

This paper presents a summary, in tabular form, of the composition of commercial coal resources of the country. Specimen analyses are given exemplifying the analysis of coal mined in each coal-producing county, or where feasible, coal from each bed in each county. Ranges of analyses are given where sufficient data permit determination of the ranges. In addition, the degree of metamorphism from lignite toward anthracite of much of the coal is indicated by classification by rank.

The bulletin is for sale by the Superintendent of Documents, Washington, D. C. Price 10 cents.

Seco

COAL SCALES

...NOW SPECIALLY
DESIGNED FOR
CONCRETE INSTALLATIONS



SECO AUTOMATIC
COAL SCALE
400LBS
18 TON PER HR. CAP.

• SECO COAL SCALES are now newly designed with an insert for concrete boiler feeding installations. This eliminates special designing on your part. SECO Coal Scales are a part of STOCK'S "BUNKER-TO-STOKER and BUNKER-TO-PULVERIZER" service. For detailed drawings, write today!

COAL VALVES, COAL SCALES
COAL DISTRIBUTORS
COMPLETE "BUNKER-TO-STOKER
AND BUNKER-TO-PULVERIZER"
INSTALLATIONS

STOCK ENGINEERING COMPANY

9807 THEODORE AVE. • CLEVELAND, OHIO

LOOKING AHEAD

In 1933, a representative group of coal producers decided to help themselves and the industry by turning, as most industries have done, to research; starting on a big job that needed doing badly, but that no one company felt justified in tackling on a broad scale. Bituminous Coal Research, Inc., was formed and it went to work.

Funds were raised from coal producers and coal carriers, and Battelle Memorial Institute, at Columbus, Ohio, was selected as the laboratory. A program was organized to apply present knowledge and current new ideas to improved domestic and industrial combustion equipment. This was the first official recognition by the industry of its obligation to provide proper apparatus for the best use of its product.

In addition to its contribution to the Battelle program, the National Coal Association, through Bituminous Coal Research, Inc., is contributing to the Coal Research Laboratory at Carnegie Institute of Technology. It has joined twenty-five leading coal producers, coal carriers, steel and chemical companies, together with Carnegie Institute of Technology, itself, in carrying out a long range fundamental research program. This activity, now twelve years old, was designed to develop basic knowledge on the chemical nature of coal, and on the processes of combustion, carbonization and liquefaction of coal. These studies should lead to improvement in the present uses of coal as well as to development of new chemical uses.

Thus the industry has a good start toward insuring its future. But let's remember it's only a start and must be expanded manyfold, soon. Why? Let's look ahead.

The chemical industry has not in the past been a quantity market for coal. The chemist was talking pounds. Now he is talking tons. Plastics, synthetic rubber, and others are expected to require hundreds of thousands of tons of raw materials annually. Practically the only sources of such quantity supply are coal, petroleum, and possibly alcohol from farm products. The coal industry can have its share of these markets or not, depending on the amount of preparatory research it is willing to do. Let us examine some of the possibilities.

Benzene

Benzene is a coke oven by-product used as a bulk chemical for many years. Much of our huge synthetic rubber program depends on it. The Buna type rubber is made by combining the two chemicals, butadiene and styrene. Styrene is now made from benzene and butadiene possibly will be in the future. Nylon and phenol plastics are dependent on benzene.

Production of benzene, now principally from coke ovens, depends on the activity of the steel industry. If it is to serve as the basic material of a large industry, other sources of production must be provided. It has been made in the laboratory by hydrogenation of coal and by oxidation treatment of coal. It has been made commercially from petroleum for some time, according to reports of the

Anglo-Iranian Oil Company, and it is now reported to be made from petroleum in this country. Research should now be under way to produce benzene directly from coal to share in this market.

Dustproofing of Coal

Last year according to statistics the coal industry used, for dust-treating, 60,000,000 gallons of oil. This industry's oil bill was about \$5,000,000. Why not make a dustproofing agent from our own coal? Tars have been used, but as such were not completely satisfactory, or generally available in mining districts. Oil products were not completely satisfactory in the beginning, either, but the oil companies developed a coal spray oil specifically for the job. Suitable coal hydrogenation and oxidation products can be made in the laboratory now, and might be made commercially from tippie dust, washery slurry and reject coal, by further research. Such accomplishment would be in effect a market for these waste products.

Hydrogenation

The hydrogenation or liquefaction of coal is not a commercial process because of low cost petroleum in this country. Partial hydrogenation, however, yields the light oils, benzene, toluene, etc., and also much larger quantities of phenolic compounds for plastics than can be obtained from the coke oven. Such a process might be operated more cheaply than complete hydrogenation and yield marketable products at competitive prices. The U. S. Bureau of Mines is now expanding its hydrogenation program.

Low-Ash Carbon

Aluminum and magnesium production has multiplied with the war. Experts predict that the postwar demand for these light metals will be much greater than at any previous time. Carbon electrodes are used in the process of refining, most of which come from petroleum and pitch coke because of the low-ash content. Low-ash carbon has been made in the laboratory from coal by dissolving it in tetralin, derived from coke-oven products, filtering the ash and coal portion resistant to attack and boiling off the solvent. In the laboratory the Pittsburgh seam coal has been so converted, yielding 70 per cent of original weight with an ash content of 0.0 to 0.5 per cent.

For aluminum, alone, our present annual rate of production is about 1,000,000,000 lb. On the conservative basis of 0.5 lb of carbon used per pound of aluminum, the demand for electrode carbon is 250,000 tons per year. Here again, grades and sizes not readily marketed might be processed and sold at a premium.

These projects cited are only a few of the many that need further research. Many are still in the laboratory stage, and time and money are required to prove their commercial possibilities. Much of the basic work has been done, however, and the research organizations are proceeding as rapidly as funds become available. They are certainly deserving of encouragement and financial support. Let's keep looking ahead.

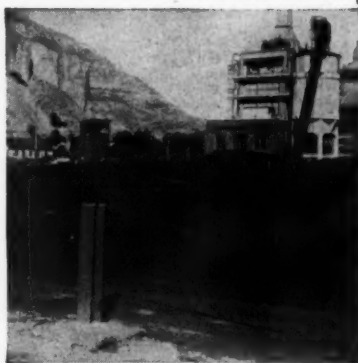
A. W. THORSON

Store and Reclaim Coal for few cents per ton

SAUERMAN Scrapers are on record as handling coal for under 2c per ton at large power plants and for only slightly more at small plants.

This operating economy is just one of many reasons why SAUERMAN Scrapers have become the most widely used equipment for open storage of coal. Other advantages are:

- Machine is simple and easy to operate. From a station overlooking the storage area the operator controls every move of the scraper through a set of automatic controls.
- The equipment is adaptable to any ground regardless of the shape or condition of the area.
- Scraper piles coal in compact layers. There is no segregation of lumps and fines; no air pockets to promote spontaneous combustion.
- Each SAUERMAN installation is a permanent, trouble-free investment. Upkeep is easy.



Picture shows coal storage yard at a 25,000 KW. central station where a 1 cu. yd. Sauerman Scraper stores and reclaims over 100,000 tons of coal per year. These scrapers are made in sizes to carry from 1/4-ton to 10-ton loads of coal.

If you have a coal storage problem write for the SAUERMAN Catalog.

SAUERMAN BROS., Inc.
550 S. Clinton Street, Chicago

SAUERMAN

POWER SCRAPERS FOR STOCKPILING



BOOKS

1—Piping Flexibility and Stresses

BY S. D. VINTERATOS AND D. R. ZENO

85 pages

Price \$3.00

Until a few years ago the methods and extent of determining the flexibility and stress of steam piping in marine work were at best only an approximation. Pressures and temperatures were low and a wide margin of error was not as a rule considered serious. At the present time, however, the majority of ships being built in this country will use steam conditions of 450 lb or higher and 750 F at the superheater outlet; for naval work temperatures have gone up to 850 F and for the Maritime Commission in a few cases to over 900 F. This calls for heavier piping and provision for greater expansion.

The authors of this book demonstrate the use of the grapho-analytical method of superposition wherein the loading and bending moments are represented diagrammatically, and the effect of each force and moment is applied separately at the end of the pipe and then, by superposing their individual effects, arrive at their resultant total. Once the grapho-analytical method is thoroughly understood, it should prove an invaluable time saver for those who have to deal with such piping problems.

2—Modern Marine Engineer's Manual

BY ALAN OSBOURNE, EDITOR-IN-CHIEF

1600 pages

Price \$6.00

In view of the greatly enlarged and accelerated program in shipbuilding now being expedited by the U. S. Maritime Commission, an additional host of qualified men will be needed to man them. To meet this need, licensed engineers are having their numbers augmented by new officers trained under the direction of the Maritime Commission.

Many of these engineers, particularly the older licensed men, will find the engineering equipment on these ships strange to them. Marine engineers' handbooks have been slow to reflect these changes. It is therefore at an opportune moment that this Manual appears to fill a vital need.

Volume 1 of the Manual embraces the following subjects: mathematics and mechanics, safety, engineering materials, pipe fittings and packings; thermodynamics; combustion; boilers; boiler operations and maintenance; reciprocating engines; marine steam turbines; bearings and shaftings; lubrication; condensers; and pumps. The operator's point of view is evident throughout the text, which has been so prepared as to anticipate questions and stimulate other questions.

3—Mechanical Engineers' Handbook (Fourth Edition)

BY LIONEL S. MARKS

2274 pages

5 × 7

Price \$7.00

Mechanical engineers will welcome the new 1941 Edition of this standard handbook as eleven years have elapsed since the appearance of the previous edition and in the interim far-reaching advances have been made in many branches of mechanical engineering. The present volume represents the work of more than 90 contributors, each a specialist in the particular subjects covered, and many of the chapters have been completely rewritten, only basic material having been retained from the previous edition.

4—Works Boiler Plant

BY F. J. MATTHEWS

181 pages

Price \$4.00

This book is offered as a guide to the operation and maintenance of the small industrial boiler plant. It will appeal to operators who are studying the subject and at the same time it should be of practical value to any one engaged in boiler room engineering, assisting in correcting faults, tracing troubles, effecting economies and other problems which arise in the daily operation of the plant.

The book comprises ten concisely written chapters covering such topics as fuel, factors, heat-recovery auxiliaries, heat economies, boiler feedwater treatment, operation and maintenance topics, and boiler-plant testing.

5—Technical Dictionary

957 pages

Price \$5.00

An important feature of this dictionary, recently compiled by British editors, is the inclusion of both the English and American terminologies where these differ from one another. Special care has been taken to do this, and leading American authorities have been consulted. Here you can find, in an instant, exact definitions of many terms you may wish to know, scientific words that are new to you, or recently coined technical terms.

The reference contains hundreds of words not found in ordinary dictionaries. It will be useful both to the specialist who wants to be familiar with terms in other fields, and to the layman who wants to know the terms used most frequently in science, engineering and industry. It meets the demand for up-to-date information as no other reference does.

It is reported to be the most comprehensive technical reference in English, with more than 50,000 entries, covering in one compact volume all branches of modern science and industry.

6—Heat Engines (Fifth Edition)

BY J. R. ALLEN AND J. A. BURSLEY

576 pages

Price \$4.00

The development of heat engines and their auxiliaries during the last ten years has made necessary a revised edition of this excellent textbook. Beginning with chapters on heat, elementary thermodynamics, properties of steam, calorimeters, fuels and combustion, the book presents fundamental principles as an approach for the student to the understanding of the problems of steam generation. Boilers and boiler auxiliaries are then discussed, followed by a chapter on power and performance of steam engines. Three chapters deal, respectively, with steam turbines, condensers, air compressors and refrigerating machinery, while the concluding chapters deal with the internal-combustion engine, its fuel and fuel systems, ignition, cooling, etc., rating and performance.

COUPON



COMBUSTION PUBLISHING COMPANY, Inc., 200 Madison Avenue, New York, N. Y.

Enclosed find check for \$ for which please send me the books listed by number.

NAME _____

Books Nos. _____

ADDRESS _____

Postage prepaid in the United States on all orders accompanied by remittance or amounting to five dollars or over.



FOR TEMPERATURES UP TO 2500°F.
in Furnaces, Ovens, Kilns, Etc.

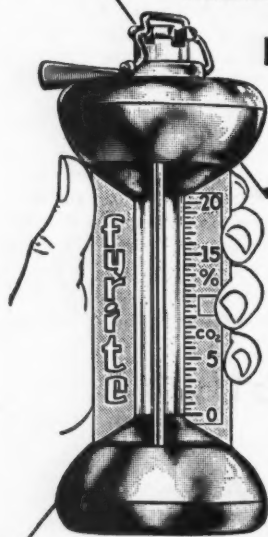
Carey HI-TEMP INSULATIONS

Use CAREY HI-TEMP Blocks, Pipe Covering and Cements for Furnaces, Ovens, Kilns, Lehrs, Regenerating Chambers, Breeches, Ducts, etc., where internal temperatures run as high as 2500 degrees F., or higher. Write for Carey Heat Insulations Catalog. Address Dept. 69.

THE PHILIP CAREY MFG. COMPANY • Lockland, Cincinnati, Ohio
Dependable Products Since 1913
IN CANADA: THE PHILIP CAREY COMPANY LTD. 501-503 BATHURST ST. TORONTO, ONT. M5T 1A5

SIMPLIFIED CO₂ ANALYZER

MAKES **ACCURATE**
FLUE GAS TESTS
EASY



The Fyrite "Orsat" Analyzer is an outstanding example of modern instrument design. Accuracy within 1/2 of 1% CO₂. Complete analysis in 40 seconds. Conveniently held in the hand while analysis is taken. Spill-proof in any position. Rugged, durable, compact. More than 7000 in use.

RETURN COUPON BELOW. Obtain literature on Fyrite and learn how to get immediate delivery under priority regulations.

\$18.50 COMPLETE WITH CASE

BACHARACH

Industrial Instrument Co.
7000 BENNETT ST.
PITTSBURGH, PA.

SEND DATA ON FYRITE "ORSAT"

Name _____
Address _____
City _____ State _____ MEM _____

*Unseen
BUT
Effective*



The De Laval-IMO pump within the oil reservoir here shown is driven by the 7200 rpm. motor to supply pressure oil for hydraulic controls. The simplicity, compactness and lightness of the IMO pump, as well as its high efficiency, recommend it for many uses where rotary pumps are desirable but have heretofore proved too cumbersome. The IMO is also used as an hydraulic motor. Ask for Publication I-97.



IMO PUMP DIVISION

of the De Laval Steam Turbine Company, Trenton, N. J.

"Observe Fire Prevention Week, October 4-10"

Advertisers in This Issue

Air Preheater Corporation, The.....	3
American Blower Corporation.....	12 and 13
Armstrong Machine Works.....	18
Bacharach Industrial Instrument Company.....	60
Bailey Meter Company.....	30 and 31
C. O. Bartlett & Snow Company, The.....	19
W. H. & L. D. Bets.....	23
Bird-Archer Company, The.....	17
Botfield Refractories Company.....	53
Brooke Engineering Company, Inc.....	44
Philip Carey Mfg. Company, The.....	60
Clarage Fan Company.....	20 and 21
Cochrane Corporation.....	33
Combustion Engineering Company, Inc.....	2nd Cover, 6 and 7
Combustion Publishing Company, Inc.—Book Department..	59
Crosby Steam Gage and Valve Company.....	15
De Laval Steam Turbine Company.....	22 and 60
Diamond Power Specialty Corporation.....	3rd Cover
Edward Valve & Mfg. Company, The.....	5
Engineer Company, The.....	32
Hagan Corporation.....	8
Hall Laboratories, Inc.....	8
Hays Corporation, The.....	50
Ingersoll-Rand Company.....	26
Johns-Manville.....	24
Johnston & Jennings Company, The.....	25
Koppers Coal.....	28
Leeds & Northrup Company.....	4
National Aluminate Corporation.....	34
Northern Equipment Company.....	2
Pittsburgh Piping & Equipment Company.....	27
Pilbrico Jointless Firebrick Company.....	14
Poole Foundry & Machine Company.....	56
Reliance Gauge Column Company.....	53
Research Corporation.....	16
Sauerman Bros., Inc.....	58
Steel and Tubes Division, Republic Steel Corporation.....	29
Stock Engineering Company.....	57
B. F. Sturtevant Company.....	10 and 11
Western Precipitation Corporation.....	4th Cover
Yarnall-Waring Company.....	